

A close-up portrait of Richard Borcherds, a man with dark hair, a beard, and glasses, smiling slightly. He is wearing a blue collared shirt. The background is dark with colorful bokeh lights.

**RICHARD
BORCHERDS**



**FIELDS
MEDALIST**

1
00:00:03,110 --> 00:00:02,389
today's guest is professor richard

2
00:00:05,190 --> 00:00:03,120
borchardt

3
00:00:07,190 --> 00:00:05,200
of uc berkeley richard is one of the

4
00:00:09,190 --> 00:00:07,200
brightest people if not the brightest

5
00:00:11,270 --> 00:00:09,200
person that i've been lucky to speak to

6
00:00:12,870 --> 00:00:11,280
on this channel he's a fields medalist

7
00:00:15,110 --> 00:00:12,880
and a fields medal is essentially the

8
00:00:17,269 --> 00:00:15,120
nobel prize equivalent of mathematics

9
00:00:19,429 --> 00:00:17,279
he was awarded this medal due to him

10
00:00:20,310 --> 00:00:19,439
proving a speculative assertion at the

11
00:00:22,310 --> 00:00:20,320
time

12
00:00:23,910 --> 00:00:22,320
put forward by conway that the that

13
00:00:24,790 --> 00:00:23,920

there's a deep connection between the

14

00:00:27,589 --> 00:00:24,800

monster group

15

00:00:29,669 --> 00:00:27,599

and the j function which is a simple or

16

00:00:31,509 --> 00:00:29,679

one of the simplest modular forms

17

00:00:33,030 --> 00:00:31,519

this is called the monstrous moonshine

18

00:00:35,190 --> 00:00:33,040

conjecture and it was proven by

19

00:00:36,950 --> 00:00:35,200

professor borcherds in the early 1990s

20

00:00:38,709 --> 00:00:36,960

when he was in his early 30s

21

00:00:40,229 --> 00:00:38,719

the monster group is the largest of all

22

00:00:42,790 --> 00:00:40,239

the sporadic simple groups

23

00:00:44,150 --> 00:00:42,800

and its order is of the size of pretty

24

00:00:46,709 --> 00:00:44,160

much all the atoms

25

00:00:49,029 --> 00:00:46,719

that comprise the earth so around 10 to

26
00:00:50,869 --> 00:00:49,039
the 53 if i'm not mistaken orchard also

27
00:00:52,630 --> 00:00:50,879
runs a wonderful youtube channel

28
00:00:54,150 --> 00:00:52,640
which the link is in the description

29
00:00:55,110 --> 00:00:54,160
it's essentially teaching graduate

30
00:00:57,029 --> 00:00:55,120
mathematics

31
00:00:59,110 --> 00:00:57,039
over the next few months i'll be asking

32
00:01:00,630 --> 00:00:59,120
mathematicians and physicists about how

33
00:01:02,310 --> 00:01:00,640
they think and how they study

34
00:01:04,549 --> 00:01:02,320
because if you're watching this you're

35
00:01:06,469 --> 00:01:04,559
likely a sagacious individual

36
00:01:07,750 --> 00:01:06,479
who knows the importance of self-study

37
00:01:09,109 --> 00:01:07,760
this is because it's often more

38
00:01:09,750 --> 00:01:09,119

important to know how to think about a

39

00:01:11,350 --> 00:01:09,760

problem

40

00:01:13,190 --> 00:01:11,360

rather than exactly how to solve this

41

00:01:15,109 --> 00:01:13,200

particular problem because the former

42

00:01:15,749 --> 00:01:15,119

generalizes to more problems and more

43

00:01:17,590 --> 00:01:15,759

solutions

44

00:01:19,109 --> 00:01:17,600

if you'd like to see more conversations

45

00:01:19,910 --> 00:01:19,119

like this then please consider

46

00:01:22,789 --> 00:01:19,920

supporting at

47

00:01:24,390 --> 00:01:22,799

patreon.com kurtjungle right now

48

00:01:25,350 --> 00:01:24,400

there's the goal of hosting multiple

49

00:01:28,469 --> 00:01:25,360

intellectuals on

50

00:01:30,390 --> 00:01:28,479

simultaneously almost like theomaki so

51
00:01:32,469 --> 00:01:30,400
that they can battle it out in real time

52
00:01:34,630 --> 00:01:32,479
the first will be bernardo castro and

53
00:01:37,190 --> 00:01:34,640
donald hoffman and jonathan verveicky

54
00:01:37,830 --> 00:01:37,200
simultaneously if i'm lucky enough to

55
00:01:41,350 --> 00:01:37,840
reach

56
00:01:43,590 --> 00:01:41,360
around 50 patrons i'll be able to host

57
00:01:44,789 --> 00:01:43,600
this conversation thank you so much to

58
00:01:46,789 --> 00:01:44,799
all my current patrons

59
00:01:48,550 --> 00:01:46,799
i hope you enjoy part of this was filmed

60
00:01:49,270 --> 00:01:48,560
as a live stream so if it looks like i'm

61
00:01:52,950 --> 00:01:49,280
reading

62
00:01:53,910 --> 00:01:52,960
question enjoy

63
00:01:55,109 --> 00:01:53,920

first of all why don't you tell the

64

00:01:56,550 --> 00:01:55,119

audience a little bit about yourself

65

00:01:57,510 --> 00:01:56,560

your interest what field of math you

66

00:02:00,149 --> 00:01:57,520

study

67

00:02:02,069 --> 00:02:00,159

um math professor working mania and

68

00:02:04,870 --> 00:02:02,079

algebra number theory

69

00:02:07,270 --> 00:02:04,880

um i did some stuff on monstrous

70

00:02:08,150 --> 00:02:07,280

moonshine about 20 or 30 years ago and

71

00:02:10,869 --> 00:02:08,160

have been

72

00:02:11,589 --> 00:02:10,879

struggling to do something similar ever

73

00:02:13,350 --> 00:02:11,599

since

74

00:02:16,229 --> 00:02:13,360

similar as in you can't announce it or

75

00:02:19,510 --> 00:02:16,239

you can well um

76
00:02:21,190 --> 00:02:19,520
i i feel like one of these people

77
00:02:22,790 --> 00:02:21,200
you know that said that the worst thing

78
00:02:23,670 --> 00:02:22,800
that can happen to a musician is they

79
00:02:25,350 --> 00:02:23,680
have a big hit

80
00:02:27,110 --> 00:02:25,360
early in their career because they spend

81
00:02:28,790 --> 00:02:27,120
the rest of their time trying to

82
00:02:30,630 --> 00:02:28,800
equal that and i feel i'm in sort of

83
00:02:32,630 --> 00:02:30,640
that position that i did

84
00:02:33,830 --> 00:02:32,640
monstrous moonshine when i was young and

85
00:02:35,509 --> 00:02:33,840
i've been

86
00:02:37,270 --> 00:02:35,519
never managed to do anything similar

87
00:02:38,949 --> 00:02:37,280
since how did you get interested in

88
00:02:41,830 --> 00:02:38,959

mathematics

89

00:02:43,430 --> 00:02:41,840

um i've always been as long as i can

90

00:02:45,430 --> 00:02:43,440

remember i mean i i think someone was

91

00:02:47,270 --> 00:02:45,440

asking me this question why did i decide

92

00:02:48,550 --> 00:02:47,280

to become a mathematician i never did

93

00:02:50,550 --> 00:02:48,560

decide i just

94

00:02:52,869 --> 00:02:50,560

was a mathematician right you equated it

95

00:02:54,470 --> 00:02:52,879

to being a dolphin or a dolphin deciding

96

00:02:55,670 --> 00:02:54,480

something like that yeah how did you

97

00:02:57,270 --> 00:02:55,680

become interested in the particular

98

00:02:59,589 --> 00:02:57,280

field that you're interested in

99

00:03:00,390 --> 00:02:59,599

oh moonshine that that was sort of by

100

00:03:03,830 --> 00:03:00,400

accident

101
00:03:04,949 --> 00:03:03,840
um i i went to a talk by john conway as

102
00:03:08,070 --> 00:03:04,959
an undergraduate

103
00:03:09,670 --> 00:03:08,080
once you know he he

104
00:03:12,470 --> 00:03:09,680
he would sometimes give undergraduate

105
00:03:14,869 --> 00:03:12,480
talks and he mentioned this

106
00:03:16,710 --> 00:03:14,879
it was about finite simple groups which

107
00:03:18,149 --> 00:03:16,720
either sort of vague idea of what they

108
00:03:19,830 --> 00:03:18,159
were and he said well there was this

109
00:03:23,350 --> 00:03:19,840
monster group with this

110
00:03:23,670 --> 00:03:23,360
dimension living in dimension one nine

111
00:03:26,229 --> 00:03:23,680
six

112
00:03:27,910 --> 00:03:26,239
eight eight three and you also mentioned

113
00:03:30,149 --> 00:03:27,920

this is the same as the coefficient of

114

00:03:32,470 --> 00:03:30,159

the elliptic modular function i was just

115

00:03:33,830 --> 00:03:32,480

you know just completely blown away by

116

00:03:36,869 --> 00:03:33,840

this it was just

117

00:03:38,789 --> 00:03:36,879

you know that these were two

118

00:03:40,309 --> 00:03:38,799

areas of mathematics that had absolutely

119

00:03:42,390 --> 00:03:40,319

nothing to do with each other there was

120

00:03:44,710 --> 00:03:42,400

this bizarre coincidence going on

121

00:03:46,309 --> 00:03:44,720

so so that's how i got interested in it

122

00:03:46,789 --> 00:03:46,319

do you find that there's some connection

123

00:03:48,470 --> 00:03:46,799

between

124

00:03:50,149 --> 00:03:48,480

unifying different fields in math and

125

00:03:51,589 --> 00:03:50,159

unifying different fields in physics

126
00:03:53,270 --> 00:03:51,599
because as you know unification happens

127
00:03:54,390 --> 00:03:53,280
frequently in physics but it seems to

128
00:03:57,429 --> 00:03:54,400
also happen in math

129
00:03:58,869 --> 00:03:57,439
there's a sort of vague analogy i mean

130
00:04:01,190 --> 00:03:58,879
one of the things i've discovered in

131
00:04:02,949 --> 00:04:01,200
math is you really want to know

132
00:04:04,710 --> 00:04:02,959
little bits of lots of different areas

133
00:04:06,149 --> 00:04:04,720
because every now and then you find some

134
00:04:08,070 --> 00:04:06,159
bizarre connection between two

135
00:04:09,589 --> 00:04:08,080
apparently different areas

136
00:04:11,990 --> 00:04:09,599
and i would guess the same is sort of

137
00:04:14,350 --> 00:04:12,000
true in physics for instance

138
00:04:15,509 --> 00:04:14,360

you know maxwell unified light and

139

00:04:18,870 --> 00:04:15,519

electromagnetism

140

00:04:20,469 --> 00:04:18,880

and that there were two apparently

141

00:04:22,150 --> 00:04:20,479

completely different areas of physics

142

00:04:25,990 --> 00:04:22,160

but maxwell happened to know about both

143

00:04:27,830 --> 00:04:26,000

of them so he was able to unify them

144

00:04:30,310 --> 00:04:27,840

i guess gravitational quantum field

145

00:04:32,390 --> 00:04:30,320

theory is another very topical example

146

00:04:34,390 --> 00:04:32,400

that they you know general relativity

147

00:04:37,030 --> 00:04:34,400

looks quite different from

148

00:04:38,550 --> 00:04:37,040

quantum mechanics and it's a big problem

149

00:04:41,030 --> 00:04:38,560

trying to

150

00:04:41,670 --> 00:04:41,040

connect them what do your average days

151
00:04:43,270 --> 00:04:41,680
look like

152
00:04:45,350 --> 00:04:43,280
do you wake up at a particular time do

153
00:04:46,390 --> 00:04:45,360
you remember i wake up at random times

154
00:04:48,469 --> 00:04:46,400
and frankly

155
00:04:52,710 --> 00:04:48,479
most of my days spent procrastinating

156
00:04:57,590 --> 00:04:55,749
um i mean supposed to be doing

157
00:04:59,430 --> 00:04:57,600
mathematics research but mathematics

158
00:05:01,430 --> 00:04:59,440
research consists mainly of trying to do

159
00:05:03,350 --> 00:05:01,440
things that don't work

160
00:05:05,430 --> 00:05:03,360
and what do you procrastinate with what

161
00:05:08,469 --> 00:05:05,440
are your advices

162
00:05:10,710 --> 00:05:08,479
oh i can procrastinate by

163
00:05:11,990 --> 00:05:10,720

making youtube videos on mathematics or

164

00:05:13,670 --> 00:05:12,000

something like that

165

00:05:15,350 --> 00:05:13,680

do you play any video games or do you go

166

00:05:17,510 --> 00:05:15,360

for walks do you have pets or kids

167

00:05:20,710 --> 00:05:17,520

i go for walks i used to have chickens

168

00:05:22,830 --> 00:05:20,720

but they they all died a few years ago

169

00:05:24,310 --> 00:05:22,840

how much time do you spend studying

170

00:05:26,230 --> 00:05:24,320

versus

171

00:05:27,749 --> 00:05:26,240

well let's say you're doing research

172

00:05:28,950 --> 00:05:27,759

some of the research is studying

173

00:05:30,710 --> 00:05:28,960

some of the research is just writing

174

00:05:32,390 --> 00:05:30,720

some of it is thinking some of it is

175

00:05:34,150 --> 00:05:32,400

collaborating

176

00:05:35,510 --> 00:05:34,160

what does that look like for you and how

177

00:05:37,189 --> 00:05:35,520

much time do you get to spend in each

178

00:05:39,590 --> 00:05:37,199

let's say on a weekly basis

179

00:05:41,110 --> 00:05:39,600

yeah um i knew an accountant once who

180

00:05:43,189 --> 00:05:41,120

said they had to spend

181

00:05:45,029 --> 00:05:43,199

for every 15 minutes of the day they had

182

00:05:47,270 --> 00:05:45,039

to write down what they were doing

183

00:05:49,830 --> 00:05:47,280

and i've never done anything like that

184

00:05:51,749 --> 00:05:49,840

and i never dared to because if i did

185

00:05:54,550 --> 00:05:51,759

i would probably be horrified at what i

186

00:05:57,590 --> 00:05:54,560

was wasting my time on all the time

187

00:06:01,110 --> 00:05:57,600

um i i just don't know

188

00:06:03,189 --> 00:06:01,120

um i probably spend far less time doing

189

00:06:04,390 --> 00:06:03,199

useful stuff than i like to imagine

190

00:06:06,710 --> 00:06:04,400

so you don't feel like you manage your

191

00:06:09,670 --> 00:06:06,720

time well it's dreadful at it

192

00:06:10,550 --> 00:06:09,680

i'm poorly organized and have atrocious

193

00:06:13,510 --> 00:06:10,560

time management

194

00:06:14,150 --> 00:06:13,520

skills let's say that you had an ideal

195

00:06:15,590 --> 00:06:14,160

day

196

00:06:17,670 --> 00:06:15,600

in terms of process so not in terms of

197

00:06:19,029 --> 00:06:17,680

outcome because your ideal day may be

198

00:06:20,790 --> 00:06:19,039

solve the riemann hypothesis in the

199

00:06:22,230 --> 00:06:20,800

morning move on to so-and-so and solve

200

00:06:26,469 --> 00:06:22,240

it so forget about that

201
00:06:28,790 --> 00:06:26,479
process that is spend four hours

202
00:06:30,070 --> 00:06:28,800
writing spend two hours answering email

203
00:06:30,870 --> 00:06:30,080
i don't know whose ideal day would be

204
00:06:32,629 --> 00:06:30,880
emails i can't

205
00:06:33,990 --> 00:06:32,639
what would your idea look like i i can't

206
00:06:36,710 --> 00:06:34,000
spend four hours a day

207
00:06:39,110 --> 00:06:36,720
working on anything i i just get too

208
00:06:41,909 --> 00:06:39,120
fidgety and impatient

209
00:06:42,950 --> 00:06:41,919
um i mean ideal day would be if i was

210
00:06:45,990 --> 00:06:42,960
able to focus

211
00:06:47,350 --> 00:06:46,000
on something that well um yes

212
00:06:49,670 --> 00:06:47,360
i mean sometimes in the past when

213
00:06:50,870 --> 00:06:49,680

mathematics when research was going well

214

00:06:52,870 --> 00:06:50,880

i could spend you know

215

00:06:56,070 --> 00:06:52,880

12 or 16 hours a day working on a

216

00:06:59,110 --> 00:06:58,629

straight or with breaks well i'd have

217

00:07:00,870 --> 00:06:59,120

lunch

218

00:07:02,629 --> 00:07:00,880

occasionally and things like that but

219

00:07:05,510 --> 00:07:02,639

yeah yeah it was

220

00:07:07,430 --> 00:07:05,520

when i was younger i really was able to

221

00:07:08,469 --> 00:07:07,440

spend many hours straight working on

222

00:07:10,469 --> 00:07:08,479

something

223

00:07:14,950 --> 00:07:10,479

now is that a function of age that

224

00:07:14,960 --> 00:07:19,589

i don't know probably

225

00:07:23,510 --> 00:07:21,430

just getting less energetic as you get

226

00:07:24,950 --> 00:07:23,520

older or something

227

00:07:27,670 --> 00:07:24,960

are you more creative now than you were

228

00:07:30,629 --> 00:07:27,680

when you were younger i don't seem to be

229

00:07:32,550 --> 00:07:30,639

i mean when i was in my 20s and 30s i

230

00:07:33,430 --> 00:07:32,560

was getting all these ideas and they all

231

00:07:34,950 --> 00:07:33,440

worked and

232

00:07:36,710 --> 00:07:34,960

these days i'm getting loads and loads

233

00:07:39,510 --> 00:07:36,720

of ideas and they all fail

234

00:07:41,510 --> 00:07:39,520

can you give an example of what an idea

235

00:07:42,950 --> 00:07:41,520

that worked for an idea that failed

236

00:07:45,589 --> 00:07:42,960

recently let's say in the past two

237

00:07:49,270 --> 00:07:45,599

months past two months

238

00:07:51,189 --> 00:07:49,280

um well

239

00:07:53,029 --> 00:07:51,199

nothing very easy to explain i mean

240

00:07:54,869 --> 00:07:53,039

they're the

241

00:07:56,950 --> 00:07:54,879

they're all rather technical ideas i

242

00:07:58,710 --> 00:07:56,960

mean i mean that's fine

243

00:08:00,550 --> 00:07:58,720

i mean i i can tell you i mean i was

244

00:08:02,309 --> 00:08:00,560

trying to find an extension of the smith

245

00:08:04,309 --> 00:08:02,319

minkowski ziggler formula to give an

246

00:08:04,790 --> 00:08:04,319

exact number for class numbers rather

247

00:08:06,309 --> 00:08:04,800

than a

248

00:08:08,390 --> 00:08:06,319

weighted sum which probably means

249

00:08:10,070 --> 00:08:08,400

absolutely nothing to most people

250

00:08:13,189 --> 00:08:10,080

you'll find that much like the audience

251
00:08:15,830 --> 00:08:13,199
of yours the audience of this channel

252
00:08:17,350 --> 00:08:15,840
they comprise extremely bright people

253
00:08:19,430 --> 00:08:17,360
some post docs some

254
00:08:20,550 --> 00:08:19,440
even professors so don't worry if you

255
00:08:21,189 --> 00:08:20,560
feel like you're going above someone's

256
00:08:23,430 --> 00:08:21,199
head

257
00:08:25,430 --> 00:08:23,440
it seems like one of the appeals of this

258
00:08:27,029 --> 00:08:25,440
podcast is the fact that we do go into

259
00:08:29,589 --> 00:08:27,039
some technicalities unlike other

260
00:08:29,909 --> 00:08:29,599
podcasts which tend to stay at a fluffy

261
00:08:31,749 --> 00:08:29,919
or

262
00:08:33,829 --> 00:08:31,759
cosmetic level well i can go into

263
00:08:35,750 --> 00:08:33,839

technicalities if you want but i suspect

264

00:08:38,870 --> 00:08:35,760

your audience is going to plummet

265

00:08:39,509 --> 00:08:38,880

but whatever what do you feel like is

266

00:08:43,190 --> 00:08:39,519

your greatest

267

00:08:46,230 --> 00:08:43,200

greatest strength

268

00:08:49,670 --> 00:08:46,240

i'm really obstinate um that i can

269

00:08:50,710 --> 00:08:49,680

keep working on a problem for i can keep

270

00:08:53,750 --> 00:08:50,720

coming back to it

271

00:08:55,190 --> 00:08:53,760

year after year and sometimes you know

272

00:08:55,670 --> 00:08:55,200

when you come back to a problem for the

273

00:08:58,310 --> 00:08:55,680

tenth

274

00:08:59,509 --> 00:08:58,320

time you finally make some progress on

275

00:09:02,949 --> 00:08:59,519

it

276

00:09:05,670 --> 00:09:02,959

um weakness over too many to think of

277

00:09:07,350 --> 00:09:05,680

um as i said i've got lousy time

278

00:09:09,509 --> 00:09:07,360

management and work skills

279

00:09:11,030 --> 00:09:09,519

i don't collaborate with people nearly

280

00:09:13,110 --> 00:09:11,040

as much as i ought to

281

00:09:14,710 --> 00:09:13,120

you know most of the top mathematicians

282

00:09:16,550 --> 00:09:14,720

have this fantastic

283

00:09:18,230 --> 00:09:16,560

network of talking to other good

284

00:09:21,110 --> 00:09:18,240

mathematicians and

285

00:09:22,470 --> 00:09:21,120

i'd i do far too little of that why is

286

00:09:25,590 --> 00:09:22,480

that

287

00:09:27,430 --> 00:09:25,600

um poor social socials i guess social

288

00:09:28,949 --> 00:09:27,440

anxiety or just poor social skills or

289

00:09:31,829 --> 00:09:28,959

disagreeableness

290

00:09:33,509 --> 00:09:31,839

um just just not very good at

291

00:09:36,389 --> 00:09:33,519

interacting with people

292

00:09:36,710 --> 00:09:36,399

and i never quite figured out how to do

293

00:09:38,230 --> 00:09:36,720

it

294

00:09:40,310 --> 00:09:38,240

i was watching one of your q and a's and

295

00:09:41,590 --> 00:09:40,320

someone said what's or who is the nicest

296

00:09:43,509 --> 00:09:41,600

mathematician and you said

297

00:09:45,350 --> 00:09:43,519

they're all pretty much nice so then if

298

00:09:46,710 --> 00:09:45,360

they're all pretty much nice that to me

299

00:09:48,630 --> 00:09:46,720

implies that you get along with them

300

00:09:49,750 --> 00:09:48,640

unless you're not being nice in return

301

00:09:52,550 --> 00:09:49,760

so why is it that you don't get along

302

00:09:54,630 --> 00:09:52,560

with them i do get along with them just

303

00:09:57,110 --> 00:09:54,640

fine it's just kind of stressful

304

00:09:59,670 --> 00:09:57,120

interacting with people so i

305

00:10:00,710 --> 00:09:59,680

just just tend to not do it unless i

306

00:10:02,550 --> 00:10:00,720

have to

307

00:10:04,389 --> 00:10:02,560

what are the advantages of that see

308

00:10:06,389 --> 00:10:04,399

there's the soul mathematician or the

309

00:10:07,509 --> 00:10:06,399

soul physicist who in isolation comes up

310

00:10:10,230 --> 00:10:07,519

with the brilliant idea

311

00:10:10,870 --> 00:10:10,240

i believe max planck was a proponent of

312

00:10:12,710 --> 00:10:10,880

that

313

00:10:14,069 --> 00:10:12,720

but then all there are obviously others

314

00:10:15,829 --> 00:10:14,079

well people have different

315

00:10:17,829 --> 00:10:15,839

styles i mean there are some people like

316

00:10:19,110 --> 00:10:17,839

a tear and say who are fantastic at

317

00:10:20,550 --> 00:10:19,120

collaboration

318

00:10:23,030 --> 00:10:20,560

and there are other people i think i

319

00:10:24,630 --> 00:10:23,040

mean perelman is an obvious example he

320

00:10:26,790 --> 00:10:24,640

he just

321

00:10:27,670 --> 00:10:26,800

went off by himself didn't talk to

322

00:10:29,990 --> 00:10:27,680

anybody else

323

00:10:32,310 --> 00:10:30,000

work for 10 or 20 years and solve this

324

00:10:33,750 --> 00:10:32,320

absolutely fantastic problem i mean that

325

00:10:37,110 --> 00:10:33,760

that's that's the sort of

326

00:10:39,430 --> 00:10:37,120

idea of what that that's a sort of one

327

00:10:40,389 --> 00:10:39,440

ideal of mathematics research you you

328

00:10:42,150 --> 00:10:40,399

you just

329

00:10:43,829 --> 00:10:42,160

solve a problem by yourself by brute

330

00:10:45,509 --> 00:10:43,839

force but it's

331

00:10:49,190 --> 00:10:45,519

actually it's very rare that that

332

00:10:52,150 --> 00:10:49,200

happens nearly all mathematics is

333

00:10:54,550 --> 00:10:52,160

done very collaboratively these days are

334

00:10:57,670 --> 00:10:54,560

there any advantages to studying math

335

00:10:58,550 --> 00:10:57,680

later in life so for example starting in

336

00:11:01,350 --> 00:10:58,560

your 20s or

337

00:11:02,949 --> 00:11:01,360

starting in your 30s or even 40s we can

338

00:11:05,110 --> 00:11:02,959

take those as three different questions

339

00:11:07,269 --> 00:11:05,120

yeah i haven't heard of any

340

00:11:09,110 --> 00:11:07,279

mathematicians who started in their 30s

341

00:11:10,949 --> 00:11:09,120

or 40s there'd been a

342

00:11:13,190 --> 00:11:10,959

a few really good mathematicians who

343

00:11:14,230 --> 00:11:13,200

started in their 20s i mean i think ed

344

00:11:16,069 --> 00:11:14,240

whitman was

345

00:11:17,670 --> 00:11:16,079

doing history as an undergraduate or

346

00:11:20,069 --> 00:11:17,680

something and only started taking math

347

00:11:23,350 --> 00:11:20,079

seriously in his twenties

348

00:11:25,350 --> 00:11:23,360

so i mean it might be possible i just

349

00:11:28,069 --> 00:11:25,360

don't know of any cases i mean it may be

350

00:11:30,069 --> 00:11:28,079

something like learning languages you

351
00:11:31,430 --> 00:11:30,079
if you learn languages when you're young

352
00:11:33,829 --> 00:11:31,440
you're much much better

353
00:11:35,590 --> 00:11:33,839
than if you start when you're older did

354
00:11:37,670 --> 00:11:35,600
you enjoy your graduate studies more

355
00:11:40,829 --> 00:11:37,680
than your undergrad

356
00:11:44,710 --> 00:11:40,839
um they were both fun i mean

357
00:11:47,030 --> 00:11:44,720
um i wouldn't say either

358
00:11:48,389 --> 00:11:47,040
i enjoyed either more than the other

359
00:11:48,949 --> 00:11:48,399
when i was watching one of your talks

360
00:11:50,790 --> 00:11:48,959
you

361
00:11:52,069 --> 00:11:50,800
mentioned quite a few times and probably

362
00:11:54,150 --> 00:11:52,079
even in some of

363
00:11:55,670 --> 00:11:54,160

your non-q a videos you mentioned that

364

00:11:57,269 --> 00:11:55,680

interest matters so if you're gonna pick

365

00:11:58,069 --> 00:11:57,279

a problem pick one that you're terribly

366

00:12:00,230 --> 00:11:58,079

interested in

367

00:12:01,269 --> 00:12:00,240

because over the long run you'll be

368

00:12:03,509 --> 00:12:01,279

faced with

369

00:12:05,509 --> 00:12:03,519

you'll be set with problems and so on

370

00:12:09,590 --> 00:12:05,519

and it had me wondering

371

00:12:10,069 --> 00:12:09,600

did you either voluntarily like force

372

00:12:11,990 --> 00:12:10,079

yourself

373

00:12:13,190 --> 00:12:12,000

or it was forced upon you have to study

374

00:12:15,590 --> 00:12:13,200

some piece of math that you

375

00:12:17,030 --> 00:12:15,600

absolutely hated and now you abhor

376

00:12:17,829 --> 00:12:17,040

studying whatever you're not interested

377

00:12:20,389 --> 00:12:17,839

in

378

00:12:22,069 --> 00:12:20,399

well i i've never actually bothered

379

00:12:25,030 --> 00:12:22,079

studying math i didn't like

380

00:12:26,710 --> 00:12:25,040

i mean i don't remember anybody past

381

00:12:29,590 --> 00:12:26,720

high school telling me to

382

00:12:30,389 --> 00:12:29,600

study math that i didn't want to i mean

383

00:12:33,430 --> 00:12:30,399

at

384

00:12:36,629 --> 00:12:33,440

just

385

00:12:38,790 --> 00:12:36,639

what you want to study i mean

386

00:12:41,110 --> 00:12:38,800

high school yes i i was forced to study

387

00:12:44,710 --> 00:12:41,120

various bits of applied math that i

388

00:12:46,470 --> 00:12:44,720

can no longer stand often solving

389

00:12:47,430 --> 00:12:46,480

mathematical problems requires a certain

390

00:12:49,509 --> 00:12:47,440

state of mind

391

00:12:51,110 --> 00:12:49,519

do you find yourself going through

392

00:12:53,269 --> 00:12:51,120

periods where you feel like

393

00:12:54,949 --> 00:12:53,279

your mind is not creative enough not

394

00:12:57,910 --> 00:12:54,959

focused enough and how do you

395

00:12:59,269 --> 00:12:57,920

solve that yeah of course well you just

396

00:13:02,389 --> 00:12:59,279

have to go off and do something

397

00:13:03,829 --> 00:13:02,399

else so um

398

00:13:05,990 --> 00:13:03,839

there are several things you can do for

399

00:13:07,829 --> 00:13:06,000

this i mean john conway told me that

400

00:13:09,750 --> 00:13:07,839

that what he he did is he always had a

401
00:13:12,230 --> 00:13:09,760
sort of background calculation so he'd

402
00:13:14,470 --> 00:13:12,240
be calculating tables of knots or

403
00:13:16,550 --> 00:13:14,480
tables of lattices or something you can

404
00:13:18,230 --> 00:13:16,560
you you can do that even if you're not

405
00:13:20,710 --> 00:13:18,240
feeling inspired and

406
00:13:22,150 --> 00:13:20,720
i think richard feynman had this idea

407
00:13:23,110 --> 00:13:22,160
that you would always do teaching as a

408
00:13:25,190 --> 00:13:23,120
sort of background

409
00:13:26,470 --> 00:13:25,200
thing and the the point in both cases is

410
00:13:27,990 --> 00:13:26,480
so that you have

411
00:13:30,470 --> 00:13:28,000
something where you can see that you're

412
00:13:32,230 --> 00:13:30,480
making progress because the i mean the

413
00:13:34,150 --> 00:13:32,240

trouble with research is most of the

414

00:13:36,069 --> 00:13:34,160

time you're you're working hard and

415

00:13:38,790 --> 00:13:36,079

making no progress at all and this is

416

00:13:41,750 --> 00:13:38,800

psychologically kind of a bit depressing

417

00:13:43,189 --> 00:13:41,760

so you need to have something something

418

00:13:45,030 --> 00:13:43,199

else you can do where you can actually

419

00:13:47,430 --> 00:13:45,040

make visible progress on it

420

00:13:49,189 --> 00:13:47,440

what's the longest lull or the longest

421

00:13:51,110 --> 00:13:49,199

involuntary cognitive hiatus you've

422

00:13:54,629 --> 00:13:51,120

experienced

423

00:13:56,790 --> 00:13:54,639

well i'd say um hard to say i mean it

424

00:13:57,990 --> 00:13:56,800

might be now um i've been working on a

425

00:14:01,030 --> 00:13:58,000

problem for

426

00:14:02,870 --> 00:14:01,040

several years and i

427

00:14:04,790 --> 00:14:02,880

i i don't know what the progress is

428

00:14:06,790 --> 00:14:04,800

because you know 20 times i think i've

429

00:14:09,829 --> 00:14:06,800

solved it and got really excited

430

00:14:11,910 --> 00:14:09,839

and and then i start to write a top and

431

00:14:13,269 --> 00:14:11,920

geez there's this huge hole i somehow

432

00:14:15,110 --> 00:14:13,279

overlooked so i go back to being

433

00:14:18,790 --> 00:14:15,120

depressed for a bit and

434

00:14:20,389 --> 00:14:18,800

and so it keeps on switching backwards

435

00:14:22,069 --> 00:14:20,399

and forwards between thinking i solved

436

00:14:23,829 --> 00:14:22,079

and thinking i haven't and i

437

00:14:25,189 --> 00:14:23,839

you know i i sometimes think that that

438

00:14:27,189 --> 00:14:25,199

sooner or later i'm going to be

439

00:14:28,710 --> 00:14:27,199

get so senile that i can't actually

440

00:14:30,629 --> 00:14:28,720

figure out what's wrong with my solution

441

00:14:32,949 --> 00:14:30,639

and then i can publish it and

442

00:14:34,310 --> 00:14:32,959

you know you know the the the the this

443

00:14:35,750 --> 00:14:34,320

is what this is actually

444

00:14:37,670 --> 00:14:35,760

unfortunately what happens to some

445

00:14:39,509 --> 00:14:37,680

mathematicians when they get old

446

00:14:41,269 --> 00:14:39,519

they sort of lose this capacity to see

447

00:14:43,189 --> 00:14:41,279

what's wrong with what they're doing

448

00:14:44,310 --> 00:14:43,199

you mentioned depression i don't know if

449

00:14:45,670 --> 00:14:44,320

you just meant that as a throwaway

450

00:14:47,670 --> 00:14:45,680

comment but do you feel like

451
00:14:49,030 --> 00:14:47,680
you're characterized by depression or

452
00:14:49,430 --> 00:14:49,040
are you just using that in the informal

453
00:14:51,509 --> 00:14:49,440
sense

454
00:14:52,870 --> 00:14:51,519
i i don't feel i've ever had anything

455
00:14:54,870 --> 00:14:52,880
i'd call depression i mean

456
00:14:57,269 --> 00:14:54,880
of course you go through phases when

457
00:15:00,790 --> 00:14:57,279
you're feeling a little bit

458
00:15:03,509 --> 00:15:00,800
less happy than usual um actually i i

459
00:15:05,430 --> 00:15:03,519
don't know i mean i

460
00:15:07,030 --> 00:15:05,440
me maybe i'm just not very good at

461
00:15:08,949 --> 00:15:07,040
spotting symptoms of depression i

462
00:15:10,389 --> 00:15:08,959
remember seeing a poster once of saying

463
00:15:13,670 --> 00:15:10,399

you know

464

00:15:14,629 --> 00:15:13,680

um look out for these typical symptoms

465

00:15:16,310 --> 00:15:14,639

of depression i

466

00:15:17,509 --> 00:15:16,320

remember being really unimpressed by

467

00:15:18,069 --> 00:15:17,519

that because i was thinking that was

468

00:15:20,069 --> 00:15:18,079

sort of

469

00:15:23,269 --> 00:15:20,079

my normal state as a graduate student i

470

00:15:25,590 --> 00:15:23,279

didn't count that as being depressed so

471

00:15:26,949 --> 00:15:25,600

maybe i just don't recognize depression

472

00:15:28,790 --> 00:15:26,959

someone asked

473

00:15:30,710 --> 00:15:28,800

what's your iq and do you have any

474

00:15:35,110 --> 00:15:30,720

methods of increasing iq

475

00:15:37,509 --> 00:15:35,120

i've no idea what my iq is and

476

00:15:39,590 --> 00:15:37,519

as far as i know the only method of

477

00:15:41,749 --> 00:15:39,600

increasing iq is to go back in time

478

00:15:42,629 --> 00:15:41,759

because your iq steadily decreases as

479

00:15:44,150 --> 00:15:42,639

you get older

480

00:15:47,030 --> 00:15:44,160

have you taken any nootropics or

481

00:15:49,350 --> 00:15:47,040

supplements to try and either stave off

482

00:15:50,710 --> 00:15:49,360

cognitive deterioration or to improve

483

00:15:53,509 --> 00:15:50,720

your cognitive state

484

00:15:54,949 --> 00:15:53,519

no idea besides caffeine i don't take

485

00:15:57,430 --> 00:15:54,959

caffeine and i don't know what a new

486

00:15:59,829 --> 00:15:57,440

tropic is and i stay well clear of

487

00:16:01,189 --> 00:15:59,839

anything that's remotely mind-altering

488

00:16:04,310 --> 00:16:01,199

you don't drink coffee

489

00:16:04,949 --> 00:16:04,320

i don't drink coffee no tea you're

490

00:16:07,509 --> 00:16:04,959

british

491

00:16:07,990 --> 00:16:07,519

no tea well i i drink tea out of

492

00:16:09,990 --> 00:16:08,000

politeness

493

00:16:11,430 --> 00:16:10,000

if someone puts it in front of me do you

494

00:16:13,430 --> 00:16:11,440

find that depression is higher in

495

00:16:14,629 --> 00:16:13,440

mathematicians than in the general

496

00:16:18,470 --> 00:16:14,639

population

497

00:16:20,230 --> 00:16:18,480

um way outside my expertise i've no idea

498

00:16:22,069 --> 00:16:20,240

what the incidence of depression is in

499

00:16:24,550 --> 00:16:22,079

either the general population or

500

00:16:25,910 --> 00:16:24,560

mathematicians i've i've never noticed

501
00:16:26,870 --> 00:16:25,920
mathematicians being particularly

502
00:16:29,269 --> 00:16:26,880
depressed but i'm

503
00:16:30,870 --> 00:16:29,279
so clueless i probably wouldn't notice

504
00:16:32,870 --> 00:16:30,880
even if they were

505
00:16:34,470 --> 00:16:32,880
i mean the reason is that you mentioned

506
00:16:35,990 --> 00:16:34,480
you read the signs of depression one

507
00:16:37,430 --> 00:16:36,000
time on a bus ad or somewhere

508
00:16:39,030 --> 00:16:37,440
and you thought oh that's my entire

509
00:16:42,069 --> 00:16:39,040
department

510
00:16:44,310 --> 00:16:42,079
well yeah but i mean i

511
00:16:45,670 --> 00:16:44,320
i i it's it's not like i'm qualified to

512
00:16:47,509 --> 00:16:45,680
actually

513
00:16:48,949 --> 00:16:47,519

diagnose people with depression or not

514

00:16:50,710 --> 00:16:48,959

it was just

515

00:16:53,189 --> 00:16:50,720

you know you you go through periods

516

00:16:54,629 --> 00:16:53,199

where you you know depression is

517

00:16:56,230 --> 00:16:54,639

you know they have things like you go

518

00:16:57,910 --> 00:16:56,240

through periods when you're

519

00:17:00,069 --> 00:16:57,920

getting nowhere feel you're getting

520

00:17:01,829 --> 00:17:00,079

nowhere and so on and that that's just

521

00:17:04,470 --> 00:17:01,839

normal for research if you're

522

00:17:06,710 --> 00:17:04,480

researching anything serious

523

00:17:08,390 --> 00:17:06,720

what's your creative process like is it

524

00:17:11,270 --> 00:17:08,400

different depending on the problem or do

525

00:17:14,470 --> 00:17:11,280

you have a general framework

526

00:17:18,309 --> 00:17:14,480

um a lot of randomness in it um

527

00:17:20,710 --> 00:17:18,319

you you just i mean i think what's the

528

00:17:22,470 --> 00:17:20,720

creative process like it's sort of like

529

00:17:24,309 --> 00:17:22,480

um you know imagine you're on one of

530

00:17:26,470 --> 00:17:24,319

these huge

531

00:17:28,069 --> 00:17:26,480

um garbage dumps that you you know you

532

00:17:29,909 --> 00:17:28,079

sometimes see in countries there are

533

00:17:31,990 --> 00:17:29,919

these garbage dumps of people

534

00:17:33,909 --> 00:17:32,000

picking over them looking for something

535

00:17:34,870 --> 00:17:33,919

interesting and research is a bit like

536

00:17:37,750 --> 00:17:34,880

that you're

537

00:17:38,470 --> 00:17:37,760

wandering around this area looking out

538

00:17:39,909 --> 00:17:38,480

for

539

00:17:42,310 --> 00:17:39,919

something that somebody else has

540

00:17:43,750 --> 00:17:42,320

overlooked and

541

00:17:45,750 --> 00:17:43,760

nearly all the time you don't find

542

00:17:46,630 --> 00:17:45,760

anything because most areas in math

543

00:17:50,150 --> 00:17:46,640

research have been

544

00:17:53,750 --> 00:17:50,160

pretty well picked over by everybody so

545

00:17:56,870 --> 00:17:53,760

you're continually trying out new things

546

00:17:57,990 --> 00:17:56,880

and 99 of the time the new thing you've

547

00:18:01,029 --> 00:17:58,000

tried out

548

00:18:02,390 --> 00:18:01,039

either doesn't work or if you work on it

549

00:18:03,270 --> 00:18:02,400

and discover that someone's already

550

00:18:05,830 --> 00:18:03,280

thought of it

551
00:18:07,590 --> 00:18:05,840
creative process is just trying to

552
00:18:09,669 --> 00:18:07,600
generate enormous numbers of

553
00:18:11,510 --> 00:18:09,679
ideas and throwing nearly all of them

554
00:18:13,350 --> 00:18:11,520
away

555
00:18:15,350 --> 00:18:13,360
actually i've heard the same something

556
00:18:17,669 --> 00:18:15,360
like this is actually supposedly true in

557
00:18:20,310 --> 00:18:17,679
business that i think um

558
00:18:21,750 --> 00:18:20,320
what is it the guy who does the gilbert

559
00:18:22,470 --> 00:18:21,760
cartoons was saying somewhere you know

560
00:18:25,990 --> 00:18:22,480
he had tried

561
00:18:26,390 --> 00:18:26,000
30 ideas for making money and and 27 of

562
00:18:28,310 --> 00:18:26,400
them

563
00:18:29,430 --> 00:18:28,320

failed or something like that right

564

00:18:31,990 --> 00:18:29,440

scott adams

565

00:18:33,750 --> 00:18:32,000

yeah so he you just keep on generating

566

00:18:34,630 --> 00:18:33,760

new ideas and discard the ones that

567

00:18:36,230 --> 00:18:34,640

don't work

568

00:18:38,070 --> 00:18:36,240

do you find you think more geometrically

569

00:18:40,070 --> 00:18:38,080

or algebraically or you think in words

570

00:18:42,549 --> 00:18:40,080

or are you thinking concepts

571

00:18:44,230 --> 00:18:42,559

uh i i tried to wonder about that and

572

00:18:45,830 --> 00:18:44,240

it's amazingly difficult to actually

573

00:18:46,630 --> 00:18:45,840

figure out what's going on in your own

574

00:18:49,909 --> 00:18:46,640

brain

575

00:18:51,190 --> 00:18:49,919

um um it's

576

00:18:53,990 --> 00:18:51,200

it's something that's very difficult to

577

00:18:55,909 --> 00:18:54,000

describe i seem to have sort of

578

00:18:57,510 --> 00:18:55,919

some sort of algorithms built into the

579

00:18:58,549 --> 00:18:57,520

brain and i sort of know how they're

580

00:19:00,870 --> 00:18:58,559

going to work

581

00:19:01,669 --> 00:19:00,880

and i just don't know how to describe

582

00:19:05,110 --> 00:19:01,679

this i mean

583

00:19:08,470 --> 00:19:05,120

there's a bit of geometric

584

00:19:11,190 --> 00:19:08,480

um imagination going on in there

585

00:19:12,549 --> 00:19:11,200

and there's a bit of algebraic

586

00:19:14,470 --> 00:19:12,559

manipulation but i don't know how the

587

00:19:17,110 --> 00:19:14,480

algebraic manipulation works because i'm

588

00:19:18,789 --> 00:19:17,120

doing things with formulas that are

589

00:19:20,390 --> 00:19:18,799

far too complicated for me to actually

590

00:19:22,310 --> 00:19:20,400

visualize i mean i

591

00:19:24,390 --> 00:19:22,320

i can't visualize the formula itself in

592

00:19:26,310 --> 00:19:24,400

my mind but somehow

593

00:19:29,990 --> 00:19:26,320

i still know what it's doing and i've

594

00:19:32,230 --> 00:19:30,000

i've no idea how this works

595

00:19:33,430 --> 00:19:32,240

um actually the mathematician jacques

596

00:19:35,270 --> 00:19:33,440

adamar once

597

00:19:38,230 --> 00:19:35,280

wrote for a lot of mathematicians asking

598

00:19:40,310 --> 00:19:38,240

them to describe how they thought um

599

00:19:41,830 --> 00:19:40,320

and i the problem is it's so long ago

600

00:19:43,510 --> 00:19:41,840

since i looked at this that i can't

601
00:19:45,029 --> 00:19:43,520
remember what he what conclusions he

602
00:19:46,870 --> 00:19:45,039
came to but

603
00:19:49,270 --> 00:19:46,880
um there have been some attempts by

604
00:19:51,669 --> 00:19:49,280
mathematicians to research this question

605
00:19:53,270 --> 00:19:51,679
i was reading penrose's emperor's new

606
00:19:55,510 --> 00:19:53,280
mind and

607
00:19:56,950 --> 00:19:55,520
for anybody who is a mathematician or

608
00:19:58,310 --> 00:19:56,960
physicist that wants to read that book

609
00:20:01,909 --> 00:19:58,320
just read the last third

610
00:20:03,510 --> 00:20:01,919
it was a slug to get through it was

611
00:20:05,190 --> 00:20:03,520
quite an ordeal to get through the first

612
00:20:06,870 --> 00:20:05,200
bit because it's so much

613
00:20:07,909 --> 00:20:06,880

retreading of similar ground and the

614

00:20:08,470 --> 00:20:07,919

last third is actually where it's

615

00:20:10,710 --> 00:20:08,480

interesting

616

00:20:11,990 --> 00:20:10,720

but in the last third he talks about

617

00:20:13,909 --> 00:20:12,000

when he was in high school

618

00:20:15,510 --> 00:20:13,919

he's noticed that he thought differently

619

00:20:17,430 --> 00:20:15,520

than his peers and then

620

00:20:18,549 --> 00:20:17,440

when he got to university he thought

621

00:20:19,990 --> 00:20:18,559

okay great i'll be around other

622

00:20:21,669 --> 00:20:20,000

mathematicians and physicists so

623

00:20:23,750 --> 00:20:21,679

we'll think alike but then he found that

624

00:20:26,070 --> 00:20:23,760

there is even more a diversity in the

625

00:20:26,789 --> 00:20:26,080

in terms of how people think what i'm

626

00:20:29,190 --> 00:20:26,799

wondering is

627

00:20:30,470 --> 00:20:29,200

have you encountered that yeah i i

628

00:20:32,950 --> 00:20:30,480

noticed this too that

629

00:20:33,990 --> 00:20:32,960

that has sort of gradually dawned on me

630

00:20:35,590 --> 00:20:34,000

that lots of people

631

00:20:38,390 --> 00:20:35,600

learn or think in completely different

632

00:20:39,430 --> 00:20:38,400

ways i mean one example is lectures i

633

00:20:41,750 --> 00:20:39,440

mean i i've always found

634

00:20:43,590 --> 00:20:41,760

lectures if i go to a lecture i fall

635

00:20:45,270 --> 00:20:43,600

asleep after 10 minutes i just can't

636

00:20:46,310 --> 00:20:45,280

stay awake and i do all my learning from

637

00:20:48,230 --> 00:20:46,320

books and

638

00:20:49,430 --> 00:20:48,240

i sort of assumed everyone was like this

639

00:20:50,710 --> 00:20:49,440

but no an

640

00:20:53,350 --> 00:20:50,720

awful lot of people do most their

641

00:20:55,750 --> 00:20:53,360

learning from lectures and just

642

00:20:57,830 --> 00:20:55,760

hardly open the textbook so so there are

643

00:21:00,870 --> 00:20:57,840

very different styles

644

00:21:04,549 --> 00:21:00,880

and again some people obviously

645

00:21:07,029 --> 00:21:04,559

very powerful geometric intuition

646

00:21:08,710 --> 00:21:07,039

and other people have some sort of very

647

00:21:09,029 --> 00:21:08,720

good intuition about something abstract

648

00:21:11,110 --> 00:21:09,039

like

649

00:21:12,470 --> 00:21:11,120

set theory and a very little geometric

650

00:21:14,390 --> 00:21:12,480

intuition and so on

651
00:21:16,870 --> 00:21:14,400
when you work do you have to have

652
00:21:18,950 --> 00:21:16,880
uninterrupted bouts of

653
00:21:20,149 --> 00:21:18,960
time exclusive to yourself so what i

654
00:21:21,909 --> 00:21:20,159
mean is

655
00:21:23,350 --> 00:21:21,919
there's this concept called deep work

656
00:21:24,870 --> 00:21:23,360
and i'm wondering if you

657
00:21:26,470 --> 00:21:24,880
instituted that where you tell i don't

658
00:21:27,830 --> 00:21:26,480
know if you're married are you married

659
00:21:29,830 --> 00:21:27,840
first of all yeah

660
00:21:31,590 --> 00:21:29,840
okay so dude tell your wife don't bother

661
00:21:33,750 --> 00:21:31,600
me for four hours because i am

662
00:21:35,029 --> 00:21:33,760
working or do you just you start working

663
00:21:36,310 --> 00:21:35,039

and then she interrupts you that's okay

664

00:21:38,870 --> 00:21:36,320

because that's your process

665

00:21:41,029 --> 00:21:38,880

well yeah i mean if i get interrupted

666

00:21:44,230 --> 00:21:41,039

which happens quite regularly i just

667

00:21:46,549 --> 00:21:44,240

pick it up later um

668

00:21:48,390 --> 00:21:46,559

it just varies i mean i think uh you

669

00:21:49,590 --> 00:21:48,400

have to be a bit like jane austen i just

670

00:21:51,909 --> 00:21:49,600

sort of remember she

671

00:21:53,909 --> 00:21:51,919

she wrote her novels in you know

672

00:21:55,669 --> 00:21:53,919

whenever she could snatch 15 minutes

673

00:21:57,270 --> 00:21:55,679

from her social life or something like

674

00:22:00,149 --> 00:21:57,280

that so you

675

00:22:01,830 --> 00:22:00,159

you you you get so you can work in

676

00:22:04,390 --> 00:22:01,840

whatever spare time you have

677

00:22:06,310 --> 00:22:04,400

do you read any non-mathematical books

678

00:22:06,630 --> 00:22:06,320

yeah i read plenty of novels and things

679

00:22:13,830 --> 00:22:06,640

and

680

00:22:14,630 --> 00:22:13,840

example of one that you particularly

681

00:22:17,830 --> 00:22:14,640

liked besides

682

00:22:22,070 --> 00:22:17,840

lord of the rings well there's

683

00:22:25,190 --> 00:22:22,080

i don't know game of thrones and um

684

00:22:33,270 --> 00:22:28,789

fairly eclectic reading i mean i like

685

00:22:35,190 --> 00:22:33,280

agatha christie novels or um

686

00:22:36,310 --> 00:22:35,200

my mind is blanking out or terry

687

00:22:38,470 --> 00:22:36,320

pratchett or

688

00:22:39,990 --> 00:22:38,480

any any light reading i mean i don't go

689

00:22:41,909 --> 00:22:40,000

around reading sort of

690

00:22:44,149 --> 00:22:41,919

the sort of deep literature that people

691

00:22:45,270 --> 00:22:44,159

in in english literature classes write

692

00:22:47,270 --> 00:22:45,280

essays about

693

00:22:48,549 --> 00:22:47,280

and i've got a copy of finnegan's wake

694

00:22:50,390 --> 00:22:48,559

up stairs and

695

00:22:53,510 --> 00:22:50,400

you know you can open it random page and

696

00:22:55,110 --> 00:22:53,520

i can't understand a single sentence

697

00:22:56,630 --> 00:22:55,120

mandalore here wants to know if you've

698

00:22:58,390 --> 00:22:56,640

read or heard of jordan peterson and

699

00:23:00,390 --> 00:22:58,400

what you think of him or his work jordan

700

00:23:01,350 --> 00:23:00,400

peterson yeah i i've got one of his

701

00:23:03,430 --> 00:23:01,360

books about

702

00:23:04,630 --> 00:23:03,440

um had the word 12 in it i seem to

703

00:23:07,029 --> 00:23:04,640

remember

704

00:23:07,990 --> 00:23:07,039

um the most important part just that

705

00:23:10,549 --> 00:23:08,000

number yeah yeah

706

00:23:12,149 --> 00:23:10,559

and i i sort of read it but must admit i

707

00:23:13,909 --> 00:23:12,159

can't remember an awful lot about it

708

00:23:16,070 --> 00:23:13,919

anymore

709

00:23:17,830 --> 00:23:16,080

do you find that you read slow when it's

710

00:23:19,270 --> 00:23:17,840

a non-mathematical book or even when

711

00:23:22,390 --> 00:23:19,280

it's a mathematical book

712

00:23:23,590 --> 00:23:22,400

uh i read math books slowly other books

713

00:23:26,950 --> 00:23:23,600

fairly fast

714

00:23:28,950 --> 00:23:26,960

i mean math books very slowly

715

00:23:30,789 --> 00:23:28,960

and it takes a long time to absorb

716

00:23:32,230 --> 00:23:30,799

what's in it if it's anything new

717

00:23:34,390 --> 00:23:32,240

okay i'm going to take a question from

718

00:23:36,390 --> 00:23:34,400

the audience here oh okay

719

00:23:38,070 --> 00:23:36,400

prime time durkheim says has he

720

00:23:40,149 --> 00:23:38,080

experienced any sort of moments of

721

00:23:41,909 --> 00:23:40,159

madness or psychological aberration

722

00:23:45,190 --> 00:23:41,919

being someone who has a lifelong habit

723

00:23:47,269 --> 00:23:45,200

of working in high math in isolation

724

00:23:48,549 --> 00:23:47,279

nothing that i've noticed but i mean if

725

00:23:50,630 --> 00:23:48,559

maybe i'm mad and

726

00:23:53,190 --> 00:23:50,640

so mad that i don't notice i'm mad who

727

00:23:57,990 --> 00:23:55,750

maybe doing mathematics obsessively is

728

00:24:01,590 --> 00:23:58,000

is itself a mad thing to do

729

00:24:04,070 --> 00:24:01,600

socolo is stan 96 says

730

00:24:05,669 --> 00:24:04,080

he said he avoids anything that is mind

731

00:24:06,310 --> 00:24:05,679

altering so do you also avoid certain

732

00:24:08,470 --> 00:24:06,320

foods

733

00:24:11,190 --> 00:24:08,480

or do you optimize your diet in general

734

00:24:13,590 --> 00:24:11,200

do you do intermittent fasting

735

00:24:17,590 --> 00:24:13,600

um i tried intermittent fasting for

736

00:24:24,549 --> 00:24:20,870

i don't think that counts yeah well

737

00:24:25,990 --> 00:24:24,559

um yeah that's infinitesimal fasting

738

00:24:27,669 --> 00:24:26,000

well yeah i mean i think i tried it for

739

00:24:29,029 --> 00:24:27,679

a day or two and it didn't seem to make

740

00:24:31,269 --> 00:24:29,039

much difference i gave up

741

00:24:34,070 --> 00:24:31,279

no i i i don't have any particular food

742

00:24:38,710 --> 00:24:36,630

and it's mostly vegetarian partly for

743

00:24:41,110 --> 00:24:38,720

health reasons but other than that

744

00:24:41,750 --> 00:24:41,120

nothing interesting how is it that you

745

00:24:44,070 --> 00:24:41,760

go about

746

00:24:45,029 --> 00:24:44,080

learning a new math and either learning

747

00:24:47,909 --> 00:24:45,039

from a new field or

748

00:24:49,029 --> 00:24:47,919

learning math in general it's very slow

749

00:24:51,269 --> 00:24:49,039

you have to

750

00:24:52,149 --> 00:24:51,279

i mean as i said i i learned by reading

751

00:24:54,870 --> 00:24:52,159

so

752

00:24:57,269 --> 00:24:54,880

what you have to do is to well i learned

753

00:24:59,430 --> 00:24:57,279

by reading and by calculating examples

754

00:25:01,190 --> 00:24:59,440

and it's a very long slow process

755

00:25:04,870 --> 00:25:01,200

learning anything i mean

756

00:25:06,390 --> 00:25:04,880

um generally you know try reading about

757

00:25:08,710 --> 00:25:06,400

it in a dozen different books

758

00:25:09,510 --> 00:25:08,720

working out lots of examples and you

759

00:25:11,350 --> 00:25:09,520

know the first

760

00:25:12,830 --> 00:25:11,360

half dozen times i try and learn it i

761

00:25:17,190 --> 00:25:12,840

just forget it again

762

00:25:18,630 --> 00:25:17,200

um i mean i i i suspect there are a lot

763

00:25:20,710 --> 00:25:18,640

of other good mathematicians who are

764

00:25:22,070 --> 00:25:20,720

much more efficient at learning things i

765

00:25:23,510 --> 00:25:22,080

mean i i get the impression there are

766

00:25:25,350 --> 00:25:23,520

some people who can learn things just by

767

00:25:27,750 --> 00:25:25,360

reading about it once but

768

00:25:28,950 --> 00:25:27,760

i've never been able to do that it's

769

00:25:30,630 --> 00:25:28,960

kind of like learning

770

00:25:33,430 --> 00:25:30,640

you know the way people learn languages

771

00:25:35,190 --> 00:25:33,440

you you learn a language by

772

00:25:37,269 --> 00:25:35,200

you you have to do a lot of repetition

773

00:25:40,230 --> 00:25:37,279

of basic stuff before it sinks in

774

00:25:41,430 --> 00:25:40,240

at least for most people and again there

775

00:25:41,990 --> 00:25:41,440

are some people who seem to be able to

776

00:25:44,950 --> 00:25:42,000

learn 10

777

00:25:45,590 --> 00:25:44,960

or 20 languages i've no idea how they do

778

00:25:47,430 --> 00:25:45,600

it

779

00:25:48,870 --> 00:25:47,440

in one of your q as you mentioned when

780

00:25:50,230 --> 00:25:48,880

someone asks you about setbacks and

781

00:25:51,269 --> 00:25:50,240

difficulties what do you do about them

782

00:25:52,710 --> 00:25:51,279

you said

783

00:25:54,950 --> 00:25:52,720

often you just ignore them because

784

00:25:57,510 --> 00:25:54,960

you'll be surprised how many problems

785

00:25:59,750 --> 00:25:57,520

disappear yeah yeah yeah this is my

786

00:26:02,549 --> 00:25:59,760

fundamental problem solving technique

787

00:26:04,630 --> 00:26:02,559

um especially when when someone else

788

00:26:06,070 --> 00:26:04,640

comes up with a problem for me to do i

789

00:26:07,430 --> 00:26:06,080

sort of figure well if it was really

790

00:26:08,789 --> 00:26:07,440

important they would have done it so i

791

00:26:10,870 --> 00:26:08,799

can just ignore it

792

00:26:12,230 --> 00:26:10,880

do you mind giving a specific example of

793

00:26:13,830 --> 00:26:12,240

a problem you ignored and then it was

794

00:26:15,990 --> 00:26:13,840

solved

795

00:26:18,710 --> 00:26:16,000

um or that you'd realize you didn't even

796

00:26:21,830 --> 00:26:18,720

have to solve it to begin with

797

00:26:25,350 --> 00:26:23,750

i actually find that's that's sort of

798

00:26:28,230 --> 00:26:25,360

true of a surprising number of problems

799

00:26:30,230 --> 00:26:28,240

actually in math research if i if i

800

00:26:31,830 --> 00:26:30,240

don't try and understand a problem and

801

00:26:33,350 --> 00:26:31,840

just sort of

802

00:26:35,350 --> 00:26:33,360

don't try and work hard in it and just

803

00:26:38,710 --> 00:26:35,360

sort of put it aside

804

00:26:39,669 --> 00:26:38,720

that then you find a month or two later

805

00:26:41,350 --> 00:26:39,679

you suddenly

806

00:26:42,789 --> 00:26:41,360

realize it's kind of obvious what you

807

00:26:45,990 --> 00:26:42,799

ought to be doing i mean

808

00:26:47,430 --> 00:26:46,000

maybe it's just my subconscious is

809

00:26:48,149 --> 00:26:47,440

working on it or something i don't

810

00:26:50,470 --> 00:26:48,159

really know

811

00:26:53,029 --> 00:26:50,480

i mean since it's subconscious i don't

812

00:26:55,990 --> 00:26:53,039

know what's going on in there

813

00:26:57,590 --> 00:26:56,000

akash says what advice does he have for

814

00:26:58,230 --> 00:26:57,600

someone in their mid-20s to learn math

815

00:26:59,990 --> 00:26:58,240

and physics

816

00:27:01,269 --> 00:27:00,000

i work in law and i'm interested in

817

00:27:03,029 --> 00:27:01,279

physics i would like to get

818

00:27:05,110 --> 00:27:03,039

a better understanding of physics now i

819

00:27:05,669 --> 00:27:05,120

know fermat and kaylee i believe were

820

00:27:06,950 --> 00:27:05,679

lawyers

821

00:27:08,710 --> 00:27:06,960

in their mid-20s when they started

822

00:27:12,230 --> 00:27:08,720

physics sorry yeah and they started

823

00:27:14,310 --> 00:27:12,240

math i mean yeah sure as you point out

824

00:27:17,029 --> 00:27:14,320

though that there are a couple of

825

00:27:19,590 --> 00:27:17,039

rather prominent examples of lawyers who

826
00:27:23,029 --> 00:27:19,600
end up being really rather good at math

827
00:27:24,710 --> 00:27:23,039
um advice i'd just say follow whatever

828
00:27:29,269 --> 00:27:24,720
you're interested in

829
00:27:31,110 --> 00:27:29,279
um i mean and what one thing

830
00:27:32,470 --> 00:27:31,120
you can do for example is you just go

831
00:27:34,950 --> 00:27:32,480
into a math library and just

832
00:27:36,630 --> 00:27:34,960
browse at random you know you can pick

833
00:27:39,590 --> 00:27:36,640
out books at random look at the first

834
00:27:41,269 --> 00:27:39,600
few pages see if it's interesting and

835
00:27:42,630 --> 00:27:41,279
if it's interesting you could go deeper

836
00:27:45,510 --> 00:27:42,640
into it um

837
00:27:46,149 --> 00:27:45,520
so i think this is an example of what i

838
00:27:48,470 --> 00:27:46,159

was saying of

839

00:27:49,190 --> 00:27:48,480

generating random ideas how do you do it

840

00:27:51,590 --> 00:27:49,200

well

841

00:27:53,269 --> 00:27:51,600

one way is just to pick out books at

842

00:27:54,230 --> 00:27:53,279

random in a math library and see what

843

00:27:57,590 --> 00:27:54,240

they say

844

00:27:58,870 --> 00:27:57,600

and again you know 90 or 99

845

00:28:00,310 --> 00:27:58,880

of the time there won't be anything

846

00:28:00,789 --> 00:28:00,320

interesting there but every now and then

847

00:28:05,350 --> 00:28:00,799

you

848

00:28:07,110 --> 00:28:05,360

really good

849

00:28:09,590 --> 00:28:07,120

what is it about infinity categories

850

00:28:12,149 --> 00:28:09,600

that you find confounding or troublesome

851

00:28:15,110 --> 00:28:12,159

the definition to start off with i mean

852

00:28:17,350 --> 00:28:15,120

it's it's one of these definitions

853

00:28:18,870 --> 00:28:17,360

i i must have read it half a dozen times

854

00:28:20,630 --> 00:28:18,880

and

855

00:28:21,909 --> 00:28:20,640

half an hour later i just totally forgot

856

00:28:24,149 --> 00:28:21,919

what the definition is

857

00:28:26,230 --> 00:28:24,159

it just it just doesn't seem to stick in

858

00:28:29,110 --> 00:28:26,240

my mind at all i mean

859

00:28:30,950 --> 00:28:29,120

most things you know i have to read them

860

00:28:33,269 --> 00:28:30,960

you know half a dozen times before they

861

00:28:34,870 --> 00:28:33,279

stick infinity categories

862

00:28:36,789 --> 00:28:34,880

i i don't know half a dozen times

863

00:28:39,029 --> 00:28:36,799

there's nowhere near enough

864

00:28:40,310 --> 00:28:39,039

have you read any of emily riehl's work

865

00:28:45,990 --> 00:28:40,320

on infinity categories

866

00:28:50,549 --> 00:28:47,990

does he somehow systematically order his

867

00:28:52,789 --> 00:28:50,559

knowledge mathematical or other

868

00:28:54,870 --> 00:28:52,799

in something like a tree of knowledge

869

00:28:55,350 --> 00:28:54,880

does he explicitly memorize theorems or

870

00:28:57,750 --> 00:28:55,360

proof

871

00:28:59,430 --> 00:28:57,760

to make use of them more easily

872

00:29:02,630 --> 00:28:59,440

absolutely not i i'm

873

00:29:05,029 --> 00:29:02,640

as i said i'm really disorganized um

874

00:29:07,029 --> 00:29:05,039

i'd i've never bothered trying to learn

875

00:29:07,669 --> 00:29:07,039

the proof of a theorem or memorize the

876

00:29:10,870 --> 00:29:07,679

theorem

877

00:29:13,350 --> 00:29:10,880

um i just sort of

878

00:29:15,110 --> 00:29:13,360

re-read them several times so i probably

879

00:29:16,789 --> 00:29:15,120

eventually do sort of know the proofs

880

00:29:18,710 --> 00:29:16,799

but i never made a conscious effort to

881

00:29:21,830 --> 00:29:18,720

memorize the proofs

882

00:29:23,510 --> 00:29:21,840

um what i do try and do is instead of

883

00:29:25,269 --> 00:29:23,520

memorizing a proof so i can write it out

884

00:29:27,590 --> 00:29:25,279

word for word

885

00:29:28,870 --> 00:29:27,600

um which is useless i mean a photocopier

886

00:29:31,830 --> 00:29:28,880

can do that

887

00:29:33,669 --> 00:29:31,840

um you somehow want to internalize the

888

00:29:36,710 --> 00:29:33,679

ideas behind

889

00:29:38,230 --> 00:29:36,720

the essential ideas in a proof and

890

00:29:40,149 --> 00:29:38,240

it's sort of very hard to explain

891

00:29:41,990 --> 00:29:40,159

exactly what this is i mean you somehow

892

00:29:43,430 --> 00:29:42,000

want to

893

00:29:45,350 --> 00:29:43,440

know the theorem well enough that you

894

00:29:47,510 --> 00:29:45,360

can actually use the ideas for something

895

00:29:49,590 --> 00:29:47,520

else which of course a photocopier can't

896

00:29:52,149 --> 00:29:49,600

do

897

00:29:55,830 --> 00:29:52,159

and what's going on in my mind when this

898

00:29:57,190 --> 00:29:55,840

is going on i just no idea

899

00:29:58,950 --> 00:29:57,200

do you find that you're happy with your

900

00:30:00,950 --> 00:29:58,960

life yeah sure

901
00:30:02,630 --> 00:30:00,960
um maybe i'm just too dumb to notice i

902
00:30:03,750 --> 00:30:02,640
shouldn't be happy but yeah yeah i'm

903
00:30:05,830 --> 00:30:03,760
generally happy

904
00:30:10,630 --> 00:30:05,840
are you increasingly sol that is with

905
00:30:15,909 --> 00:30:13,190
about the same not something i pay a lot

906
00:30:17,510 --> 00:30:15,919
of attention to but

907
00:30:21,350 --> 00:30:17,520
what are the most meaningful aspects of

908
00:30:24,710 --> 00:30:21,360
your life doing math mainly

909
00:30:29,269 --> 00:30:24,720
relationships well i've

910
00:30:30,950 --> 00:30:29,279
i've got two kids and i'm married yeah

911
00:30:32,230 --> 00:30:30,960
do you find the relationship with your

912
00:30:34,310 --> 00:30:32,240
kids to be more meaningful than the

913
00:30:37,590 --> 00:30:34,320

mathematics

914

00:30:39,669 --> 00:30:37,600

it's different i mean and i'm not sure

915

00:30:42,870 --> 00:30:39,679

you can really compare them they're

916

00:30:45,110 --> 00:30:42,880

quite different sorts of relationships

917

00:30:46,470 --> 00:30:45,120

okay how about this all the major math

918

00:30:49,590 --> 00:30:46,480

theorems that you want

919

00:30:51,029 --> 00:30:49,600

solved are solved and you have

920

00:30:54,310 --> 00:30:51,039

as much money as you like what do you do

921

00:30:58,070 --> 00:30:54,320

with your time sleep i don't know

922

00:31:00,070 --> 00:30:58,080

um i've no idea um

923

00:31:01,830 --> 00:31:00,080

i mean i spent all my life basically my

924

00:31:03,669 --> 00:31:01,840

spare time has been spent thinking about

925

00:31:04,630 --> 00:31:03,679

mathematics if there was no mathematics

926
00:31:07,669 --> 00:31:04,640
left to do i

927
00:31:10,950 --> 00:31:07,679
really don't know um

928
00:31:14,230 --> 00:31:12,630
maybe just read math for fun or

929
00:31:16,789 --> 00:31:14,240
something i mean it's it's

930
00:31:18,389 --> 00:31:16,799
still quite i mean even if you're not

931
00:31:20,310 --> 00:31:18,399
actually doing research it's still quite

932
00:31:22,389 --> 00:31:20,320
interesting just reading other people's

933
00:31:24,230 --> 00:31:22,399
theorems and their research

934
00:31:25,669 --> 00:31:24,240
so it would be a bit like me asking a

935
00:31:27,669 --> 00:31:25,679
dolphin what if you weren't a dolphin

936
00:31:31,029 --> 00:31:27,679
anymore and it can't conceptualize it

937
00:31:32,950 --> 00:31:31,039
yeah yeah i mean it's it's just

938
00:31:34,789 --> 00:31:32,960

the question doesn't actually mean very

939

00:31:36,149 --> 00:31:34,799

much what was it like to win the fields

940

00:31:40,950 --> 00:31:36,159

medal

941

00:31:45,590 --> 00:31:41,610

yeah um

942

00:31:50,470 --> 00:31:48,549

i mean it didn't really mean very much i

943

00:31:53,190 --> 00:31:50,480

mean it was just a sort of

944

00:31:55,509 --> 00:31:53,200

rather embarrassing ceremony where where

945

00:31:56,230 --> 00:31:55,519

i when i sort of froze as far as i

946

00:32:00,389 --> 00:31:56,240

remember

947

00:32:02,070 --> 00:32:00,399

and they they you know actually proving

948

00:32:03,750 --> 00:32:02,080

proving the theorems is fun you feel

949

00:32:05,750 --> 00:32:03,760

very excited when you've done that

950

00:32:08,710 --> 00:32:05,760

but but you know getting a medal or

951
00:32:10,950 --> 00:32:08,720
something for it is just

952
00:32:11,909 --> 00:32:10,960
just sort of nothing the the only

953
00:32:15,750 --> 00:32:11,919
advantage of it

954
00:32:17,110 --> 00:32:15,760
is is as you stop is you stop worrying

955
00:32:18,549 --> 00:32:17,120
about getting these

956
00:32:20,470 --> 00:32:18,559
these things when you realize how

957
00:32:21,830 --> 00:32:20,480
unimportant they are

958
00:32:23,350 --> 00:32:21,840
when you talked about math you mentioned

959
00:32:24,870 --> 00:32:23,360
that it was it's meaningful to you maybe

960
00:32:26,310 --> 00:32:24,880
one of the most meaningful if not the

961
00:32:27,029 --> 00:32:26,320
most meaningful aspect of your life so

962
00:32:29,269 --> 00:32:27,039
what is it

963
00:32:31,990 --> 00:32:29,279

particularly about math that you find

964

00:32:36,870 --> 00:32:34,470

it's understanding it's part of

965

00:32:38,149 --> 00:32:36,880

understanding how the universe

966

00:32:40,230 --> 00:32:38,159

works you know there are all these

967

00:32:41,830 --> 00:32:40,240

fundamental questions like why does the

968

00:32:43,590 --> 00:32:41,840

universe exist and what are the

969

00:32:47,269 --> 00:32:43,600

fundamental laws of physics

970

00:32:50,389 --> 00:32:47,279

and mathematics is part of that um

971

00:32:51,430 --> 00:32:50,399

so um whenever you're doing mathematics

972

00:32:53,990 --> 00:32:51,440

you sort of

973

00:32:55,830 --> 00:32:54,000

it every piece of mathematics is helping

974

00:32:58,070 --> 00:32:55,840

you a little bit to understand how the

975

00:33:01,029 --> 00:32:58,080

universe works maybe not very much

976
00:33:01,830 --> 00:33:01,039
but um you know the universe as far as

977
00:33:04,070 --> 00:33:01,840
we can tell from

978
00:33:05,909 --> 00:33:04,080
physics the universe is running mainly

979
00:33:09,110 --> 00:33:05,919
on mathematics although we

980
00:33:10,310 --> 00:33:09,120
haven't yet quite figured out the exact

981
00:33:12,470 --> 00:33:10,320
mathematics behind

982
00:33:13,750 --> 00:33:12,480
it does that mean that you have the

983
00:33:16,310 --> 00:33:13,760
sense that when you're

984
00:33:18,549 --> 00:33:16,320
performing math you're engaged in an act

985
00:33:21,430 --> 00:33:18,559
of discovery rather than invention

986
00:33:21,830 --> 00:33:21,440
oh very much so um mathematics is yeah

987
00:33:26,630 --> 00:33:21,840
the

988
00:33:29,430 --> 00:33:26,640

invent or discover math and i'd say it's

989

00:33:31,269 --> 00:33:29,440

entirely discovered not invented well

990

00:33:33,190 --> 00:33:31,279

there are one or two areas i won't

991

00:33:34,470 --> 00:33:33,200

mention where i would say it's invented

992

00:33:36,549 --> 00:33:34,480

and

993

00:33:37,590 --> 00:33:36,559

totally useless but but almost all

994

00:33:38,789 --> 00:33:37,600

mathematics it's

995

00:33:41,669 --> 00:33:38,799

you're discovering something that's

996

00:33:43,350 --> 00:33:41,679

already there so a classical example of

997

00:33:46,310 --> 00:33:43,360

this is the

998

00:33:47,990 --> 00:33:46,320

monster sporadic simple group and this

999

00:33:50,630 --> 00:33:48,000

this has always

1000

00:33:51,990 --> 00:33:50,640

really amazed me because you know the

1001

00:33:54,310 --> 00:33:52,000

axioms for a finite simple

1002

00:33:55,990 --> 00:33:54,320

group are so trivial you you can write

1003

00:33:57,750 --> 00:33:56,000

them out in one line and they're very

1004

00:33:59,029 --> 00:33:57,760

true they're natural and then the

1005

00:34:01,909 --> 00:33:59,039

monster simple group is

1006

00:34:03,430 --> 00:34:01,919

somehow hidden in this single line so

1007

00:34:05,509 --> 00:34:03,440

we've got this monster simple group with

1008

00:34:07,990 --> 00:34:05,519

what 10 to the 54 elements and this

1009

00:34:11,030 --> 00:34:08,000

fantastically intricate structure

1010

00:34:12,629 --> 00:34:11,040

somehow hiding in this trivial one-line

1011

00:34:14,470 --> 00:34:12,639

definition

1012

00:34:15,750 --> 00:34:14,480

and a lot of the best mathematics is

1013

00:34:18,869 --> 00:34:15,760

like that you

1014

00:34:20,869 --> 00:34:18,879

you you know you you

1015

00:34:22,550 --> 00:34:20,879

you've got some sort of box that looks

1016

00:34:26,149 --> 00:34:22,560

just like a plain small

1017

00:34:28,389 --> 00:34:26,159

box without anything figuring it out and

1018

00:34:31,589 --> 00:34:28,399

you open it up and somehow there's this

1019

00:34:33,190 --> 00:34:31,599

massive diamond inside it with no

1020

00:34:34,310 --> 00:34:33,200

indication on the outside of the box

1021

00:34:37,190 --> 00:34:34,320

there's anything

1022

00:34:38,069 --> 00:34:37,200

like that in it what is it about the

1023

00:34:39,589 --> 00:34:38,079

monster group

1024

00:34:41,909 --> 00:34:39,599

or the monster the sporadic monster

1025

00:34:43,909 --> 00:34:41,919

group that you find fascinating because

1026
00:34:45,109 --> 00:34:43,919
to an outsider so let's say someone

1027
00:34:46,790 --> 00:34:45,119
who's not interested in math

1028
00:34:48,710 --> 00:34:46,800
to say that it's interesting is almost

1029
00:34:50,790 --> 00:34:48,720
as arbitrary as saying

1030
00:34:53,270 --> 00:34:50,800
why are there six platonic solids or why

1031
00:34:56,629 --> 00:34:53,280
does the number 1740 exist

1032
00:34:57,829 --> 00:34:56,639
yeah um because we don't understand why

1033
00:35:00,390 --> 00:34:57,839
the monster exists

1034
00:35:02,470 --> 00:35:00,400
i mean you know so there's this

1035
00:35:03,030 --> 00:35:02,480
classification of the finite simple

1036
00:35:05,190 --> 00:35:03,040
groups

1037
00:35:06,630 --> 00:35:05,200
and the classification says well there

1038
00:35:09,510 --> 00:35:06,640

are these infinite families

1039

00:35:10,950 --> 00:35:09,520

and okay infinite families of things are

1040

00:35:13,510 --> 00:35:10,960

kind of uninteresting and

1041

00:35:14,870 --> 00:35:13,520

well okay they're not uninteresting but

1042

00:35:16,390 --> 00:35:14,880

most mathematicians find them very

1043

00:35:19,670 --> 00:35:16,400

interesting but

1044

00:35:21,270 --> 00:35:19,680

um finding an infinite family of things

1045

00:35:22,790 --> 00:35:21,280

isn't too surprising but but the

1046

00:35:24,310 --> 00:35:22,800

classification says there are these

1047

00:35:25,109 --> 00:35:24,320

infinite families like alternating

1048

00:35:28,630 --> 00:35:25,119

groups and then there

1049

00:35:29,990 --> 00:35:28,640

are 26 others left over which

1050

00:35:32,550 --> 00:35:30,000

there's no obvious reason why they

1051
00:35:34,150 --> 00:35:32,560
should exist and the infinite families

1052
00:35:35,829 --> 00:35:34,160
you can sort of think of a reason why

1053
00:35:36,710 --> 00:35:35,839
they exist i mean you know they're

1054
00:35:38,310 --> 00:35:36,720
they're

1055
00:35:39,990 --> 00:35:38,320
general linear groups and they exist

1056
00:35:41,510 --> 00:35:40,000
because they're symmetries of vector

1057
00:35:43,829 --> 00:35:41,520
spaces

1058
00:35:45,510 --> 00:35:43,839
it's a very natural explanation and then

1059
00:35:47,910 --> 00:35:45,520
you have these sporadic simple groups

1060
00:35:50,150 --> 00:35:47,920
exist and they exist because

1061
00:35:51,270 --> 00:35:50,160
well nobody really has any idea why they

1062
00:35:53,829 --> 00:35:51,280
exist there's

1063
00:35:54,950 --> 00:35:53,839

there's no explanation for them beyond

1064

00:35:56,829 --> 00:35:54,960

going through

1065

00:35:59,030 --> 00:35:56,839

you know 10 000 pages of the

1066

00:36:01,510 --> 00:35:59,040

classification

1067

00:36:03,990 --> 00:36:01,520

um so this this may be one of these

1068

00:36:05,430 --> 00:36:04,000

unanswerable questions like you know

1069

00:36:07,990 --> 00:36:05,440

what i mentioned is why does the

1070

00:36:09,829 --> 00:36:08,000

universe exist um

1071

00:36:11,030 --> 00:36:09,839

i mean maybe it just doesn't have an

1072

00:36:15,510 --> 00:36:11,040

answer

1073

00:36:17,349 --> 00:36:15,520

the problem i just cannot imagine

1074

00:36:19,349 --> 00:36:17,359

how you could even answer the question

1075

00:36:20,950 --> 00:36:19,359

why does the universe exist i mean

1076
00:36:22,710 --> 00:36:20,960
imagine an answer that would satisfy you

1077
00:36:24,950 --> 00:36:22,720
as to why the monster group exists what

1078
00:36:28,870 --> 00:36:24,960
would that even look like

1079
00:36:30,870 --> 00:36:28,880
um one one thing might be that

1080
00:36:32,950 --> 00:36:30,880
you know that there's some very natural

1081
00:36:36,470 --> 00:36:32,960
class of geometric objects

1082
00:36:38,790 --> 00:36:36,480
whose symmetries are the

1083
00:36:40,630 --> 00:36:38,800
um sporadic simple groups and people

1084
00:36:43,270 --> 00:36:40,640
have been searching for this for

1085
00:36:45,670 --> 00:36:43,280
decades and no one has ever found any

1086
00:36:49,030 --> 00:36:45,680
plausible candidates

1087
00:36:50,310 --> 00:36:49,040
so um

1088
00:36:51,910 --> 00:36:50,320

i mean for instance the infinite

1089

00:36:53,030 --> 00:36:51,920

families of groups there is a sort of

1090

00:36:56,870 --> 00:36:53,040

natural answer they

1091

00:36:59,190 --> 00:36:56,880

that they all act that the the they

1092

00:37:00,310 --> 00:36:59,200

all have these structures called bn

1093

00:37:02,550 --> 00:37:00,320

pairs

1094

00:37:03,349 --> 00:37:02,560

and this sort of gives an explanation of

1095

00:37:05,670 --> 00:37:03,359

them

1096

00:37:07,270 --> 00:37:05,680

that there's a uniform construction of

1097

00:37:10,710 --> 00:37:07,280

all the

1098

00:37:12,310 --> 00:37:10,720

that aren't sporadic you know there's

1099

00:37:13,750 --> 00:37:12,320

sort of one construction that works for

1100

00:37:16,150 --> 00:37:13,760

all of them you just

1101
00:37:17,829 --> 00:37:16,160
twiddle a few parameters and you you get

1102
00:37:19,750 --> 00:37:17,839
out all of them but for the spreadings

1103
00:37:21,270 --> 00:37:19,760
there's nothing like that

1104
00:37:23,750 --> 00:37:21,280
what is it about quantum field theory

1105
00:37:26,069 --> 00:37:23,760
that you find difficult

1106
00:37:27,670 --> 00:37:26,079
um in our email exchange you mentioned

1107
00:37:31,109 --> 00:37:27,680
that it gives you a headache

1108
00:37:33,190 --> 00:37:31,119
yeah i think the problem is that

1109
00:37:34,870 --> 00:37:33,200
mathematicians are trained that

1110
00:37:35,670 --> 00:37:34,880
everything should be really precisely

1111
00:37:37,670 --> 00:37:35,680
defined

1112
00:37:39,510 --> 00:37:37,680
and you you shouldn't go into the next

1113
00:37:41,349 --> 00:37:39,520

step before you've completely understood

1114

00:37:43,270 --> 00:37:41,359

all the previous steps

1115

00:37:44,870 --> 00:37:43,280

and quantum field theory just isn't like

1116

00:37:48,150 --> 00:37:44,880

that things just

1117

00:37:50,790 --> 00:37:48,160

aren't precisely defined and if you try

1118

00:37:52,550 --> 00:37:50,800

and really find out what the definition

1119

00:37:54,630 --> 00:37:52,560

is you find there's nothing there and it

1120

00:37:57,910 --> 00:37:54,640

just doesn't make sense

1121

00:38:00,230 --> 00:37:57,920

um so do you mind giving an example yeah

1122

00:38:01,910 --> 00:38:00,240

sure if you look at Feynman diagrams

1123

00:38:03,670 --> 00:38:01,920

for example there are

1124

00:38:05,910 --> 00:38:03,680

um that they give you a sort of

1125

00:38:08,630 --> 00:38:05,920

asymptotic expansion of something like a

1126

00:38:11,030 --> 00:38:08,640

scattering coefficient or whatever

1127

00:38:11,990 --> 00:38:11,040

so it's a well-defined asymptotic

1128

00:38:13,990 --> 00:38:12,000

expansion

1129

00:38:17,670 --> 00:38:14,000

you can sort of make sense of that and

1130

00:38:20,470 --> 00:38:17,680

it's an asymptotic expansion of

1131

00:38:21,430 --> 00:38:20,480

and at that point you suddenly get stuck

1132

00:38:22,790 --> 00:38:21,440

um

1133

00:38:25,030 --> 00:38:22,800

no one has actually figured out what

1134

00:38:27,910 --> 00:38:25,040

it's an asymptotic expansion of

1135

00:38:28,950 --> 00:38:27,920

so in some sense it doesn't really make

1136

00:38:31,510 --> 00:38:28,960

sense

1137

00:38:33,510 --> 00:38:31,520

and what is even more annoying is it i

1138

00:38:34,790 --> 00:38:33,520

mean if it didn't make sense i could

1139

00:38:36,710 --> 00:38:34,800

cope with that

1140

00:38:38,870 --> 00:38:36,720

the trouble is that it doesn't make

1141

00:38:40,790 --> 00:38:38,880

sense and it gives answers that you can

1142

00:38:43,510 --> 00:38:40,800

check in experiments and this is

1143

00:38:45,109 --> 00:38:43,520

really annoying because you know

1144

00:38:46,950 --> 00:38:45,119

theoretically it doesn't make sense but

1145

00:38:48,470 --> 00:38:46,960

experimentally it does so there's this

1146

00:38:51,750 --> 00:38:48,480

horrible conflict

1147

00:38:54,870 --> 00:38:51,760

um um so

1148

00:38:56,230 --> 00:38:54,880

and so so i mean in some sense the

1149

00:38:57,670 --> 00:38:56,240

fundamental problem of

1150

00:38:59,510 --> 00:38:57,680

quantum field theory is to give a

1151

00:39:00,710 --> 00:38:59,520

rigorous definition of it there still

1152

00:39:02,150 --> 00:39:00,720

isn't one

1153

00:39:05,190 --> 00:39:02,160

well people have given rigorous

1154

00:39:07,430 --> 00:39:05,200

definitions the trouble is

1155

00:39:08,870 --> 00:39:07,440

the the the quantum field theories that

1156

00:39:11,670 --> 00:39:08,880

people actually use

1157

00:39:13,510 --> 00:39:11,680

in the standard model don't fit these

1158

00:39:16,390 --> 00:39:13,520

rigorous definitions or at least no one

1159

00:39:19,510 --> 00:39:16,400

has managed to prove that they do

1160

00:39:22,470 --> 00:39:19,520

and so this has been an open problem for

1161

00:39:24,390 --> 00:39:22,480

maybe 90 years or so do you have any

1162

00:39:26,150 --> 00:39:24,400

thoughts on the existence of free will

1163

00:39:28,390 --> 00:39:26,160

do you think you have free will and if

1164

00:39:30,230 --> 00:39:28,400

not then why not if so why so

1165

00:39:31,589 --> 00:39:30,240

how are you defining it i thought about

1166

00:39:32,950 --> 00:39:31,599

this a bit and what i

1167

00:39:34,870 --> 00:39:32,960

eventually came to the conclusion was

1168

00:39:35,829 --> 00:39:34,880

that i didn't even know how to define

1169

00:39:39,510 --> 00:39:35,839

what free will

1170

00:39:41,030 --> 00:39:39,520

was so if you can't define something

1171

00:39:41,750 --> 00:39:41,040

precisely it makes it very hard to

1172

00:39:45,030 --> 00:39:41,760

discuss

1173

00:39:47,349 --> 00:39:45,040

in fact this this is a big problem with

1174

00:39:48,950 --> 00:39:47,359

an awful lot of philosophical questions

1175

00:39:51,030 --> 00:39:48,960

if you look at them close enough you

1176

00:39:53,589 --> 00:39:51,040

discover the terms in them are simply

1177

00:39:56,710 --> 00:39:53,599

not well defined enough to talk about

1178

00:39:59,109 --> 00:39:56,720

so can you even define free will can you

1179

00:40:02,069 --> 00:39:59,119

talk about it not as a mathematician but

1180

00:40:02,950 --> 00:40:02,079

let's say as a regular person about what

1181

00:40:05,910 --> 00:40:02,960

free will

1182

00:40:06,710 --> 00:40:05,920

is that there's the slippery definition

1183

00:40:08,950 --> 00:40:06,720

but so

1184

00:40:10,470 --> 00:40:08,960

there is also a slippery definition as

1185

00:40:13,190 --> 00:40:10,480

to what constitutes a chair

1186

00:40:14,470 --> 00:40:13,200

or i or you and presumably you've used

1187

00:40:16,470 --> 00:40:14,480

those in sentences before

1188

00:40:18,790 --> 00:40:16,480

with facility well that so can you do

1189

00:40:20,870 --> 00:40:18,800

this yeah i i can sort of

1190

00:40:22,790 --> 00:40:20,880

vaguely define a chair in some way that

1191

00:40:23,190 --> 00:40:22,800

i can most the time recognize a chair

1192

00:40:27,270 --> 00:40:23,200

i've

1193

00:40:28,870 --> 00:40:27,280

just cannot come up with a definition i

1194

00:40:30,470 --> 00:40:28,880

poached around a bit as far as i can

1195

00:40:33,750 --> 00:40:30,480

figure out nobody else has come up with

1196

00:40:35,670 --> 00:40:33,760

a convincing definition either

1197

00:40:37,589 --> 00:40:35,680

i mean you certainly have this feeling

1198

00:40:40,950 --> 00:40:37,599

in inside yourself

1199

00:40:43,109 --> 00:40:40,960

that you can choose what to do but

1200

00:40:44,069 --> 00:40:43,119

um you know maybe this feeling is an

1201
00:40:47,910 --> 00:40:44,079
illusion

1202
00:40:50,230 --> 00:40:47,920
and everything we do is determined by

1203
00:40:51,990 --> 00:40:50,240
some laws of physics and we just have

1204
00:40:53,750 --> 00:40:52,000
this illusion that

1205
00:40:56,150 --> 00:40:53,760
we're choosing what these laws of

1206
00:40:58,230 --> 00:40:56,160
physics do

1207
00:41:00,309 --> 00:40:58,240
but i don't know i mean i i can't even

1208
00:41:02,870 --> 00:41:00,319
define what is meant by

1209
00:41:03,910 --> 00:41:02,880
having a feeling that we we can choose

1210
00:41:07,030 --> 00:41:03,920
what to do

1211
00:41:08,790 --> 00:41:07,040
so you're agnostic on the issue i'm

1212
00:41:10,870 --> 00:41:08,800
i think it's even worse than being

1213
00:41:12,470 --> 00:41:10,880

agnostic i i'd say i i don't

1214

00:41:14,150 --> 00:41:12,480

i'm not saying i don't know what the

1215

00:41:15,670 --> 00:41:14,160

answer to the question is i'm saying i

1216

00:41:17,829 --> 00:41:15,680

i don't even know what the question

1217

00:41:19,349 --> 00:41:17,839

means and i not at all sure it even

1218

00:41:22,230 --> 00:41:19,359

makes sense

1219

00:41:23,030 --> 00:41:22,240

what about god do you believe in god and

1220

00:41:24,790 --> 00:41:23,040

the same problem

1221

00:41:26,470 --> 00:41:24,800

uh before we start discussing god i

1222

00:41:27,190 --> 00:41:26,480

would like you to define what you mean

1223

00:41:29,589 --> 00:41:27,200

by the term

1224

00:41:31,109 --> 00:41:29,599

god because there are so many different

1225

00:41:33,030 --> 00:41:31,119

definitions

1226

00:41:35,190 --> 00:41:33,040

um so you could have a god of your

1227

00:41:37,109 --> 00:41:35,200

favorite religion saying it's this

1228

00:41:39,190 --> 00:41:37,119

guy who maybe zaps people with

1229

00:41:41,750 --> 00:41:39,200

thunderbolts or whatever

1230

00:41:42,230 --> 00:41:41,760

or you could say you know god is just a

1231

00:41:44,150 --> 00:41:42,240

name

1232

00:41:45,670 --> 00:41:44,160

for the underlying essence of the

1233

00:41:48,710 --> 00:41:45,680

universe which is sort of

1234

00:41:51,109 --> 00:41:48,720

maybe meaningless but you could say in

1235

00:41:52,710 --> 00:41:51,119

in that sense god exists because it's

1236

00:41:54,710 --> 00:41:52,720

god is just a name for whatever the

1237

00:41:55,670 --> 00:41:54,720

explanation of the universe is so there

1238

00:41:57,589 --> 00:41:55,680

are

1239

00:41:59,190 --> 00:41:57,599

all these different possible definitions

1240

00:42:02,309 --> 00:41:59,200

of god and

1241

00:42:04,069 --> 00:42:02,319

some of them that you

1242

00:42:05,670 --> 00:42:04,079

you could recently say they do exist

1243

00:42:06,950 --> 00:42:05,680

some of them you could say

1244

00:42:08,790 --> 00:42:06,960

there seems to be very little evidence

1245

00:42:10,630 --> 00:42:08,800

for it and others it's just not clear

1246

00:42:12,309 --> 00:42:10,640

what the question means so

1247

00:42:13,670 --> 00:42:12,319

before discussing this philosophical

1248

00:42:15,990 --> 00:42:13,680

question let's first have some

1249

00:42:17,670 --> 00:42:16,000

precise definitions you mentioned one

1250

00:42:18,390 --> 00:42:17,680

that god is the universe in some way

1251
00:42:21,270 --> 00:42:18,400
shape or form

1252
00:42:22,309 --> 00:42:21,280
now why is that meaningless well it

1253
00:42:23,910 --> 00:42:22,319
because

1254
00:42:25,670 --> 00:42:23,920
it's just words it doesn't actually tell

1255
00:42:27,349 --> 00:42:25,680
you anything more about the universe

1256
00:42:29,109 --> 00:42:27,359
that you didn't already know

1257
00:42:30,630 --> 00:42:29,119
um so that there's a whole lot of

1258
00:42:31,270 --> 00:42:30,640
questions like this you could say you

1259
00:42:34,390 --> 00:42:31,280
know the

1260
00:42:38,630 --> 00:42:34,400
the universe is really a simulation or

1261
00:42:40,710 --> 00:42:38,640
the universe is um a cellular automaton

1262
00:42:41,750 --> 00:42:40,720
or maybe there are lots of parallel

1263
00:42:44,710 --> 00:42:41,760

universes

1264

00:42:46,230 --> 00:42:44,720

and none of these actually say anything

1265

00:42:47,190 --> 00:42:46,240

whatsoever about the universe i mean

1266

00:42:49,270 --> 00:42:47,200

that they're all

1267

00:42:51,670 --> 00:42:49,280

great plots for comic book stories or

1268

00:42:52,790 --> 00:42:51,680

whatever but

1269

00:42:54,390 --> 00:42:52,800

you know what what's the difference

1270

00:42:55,910 --> 00:42:54,400

between the universe being a cellular

1271

00:42:58,230 --> 00:42:55,920

automaton the universe not being a

1272

00:42:59,589 --> 00:42:58,240

cellular automaton well i've

1273

00:43:02,550 --> 00:42:59,599

there just doesn't seem to be any

1274

00:43:03,589 --> 00:43:02,560

difference or what what's the universe

1275

00:43:05,910 --> 00:43:03,599

what's the difference between there

1276

00:43:07,430 --> 00:43:05,920

being a sort of pantheistic god

1277

00:43:09,510 --> 00:43:07,440

underlying everything or they're not

1278

00:43:12,470 --> 00:43:09,520

being a pantheistic god well

1279

00:43:13,430 --> 00:43:12,480

i've no idea it it just seems to be a

1280

00:43:16,550 --> 00:43:13,440

content-free

1281

00:43:18,550 --> 00:43:16,560

sentence in your psychology and your

1282

00:43:19,990 --> 00:43:18,560

mindset nothing would be changed if you

1283

00:43:21,190 --> 00:43:20,000

found out that you were the only

1284

00:43:24,550 --> 00:43:21,200

conscious person

1285

00:43:25,829 --> 00:43:24,560

or that you were living in a dream i i

1286

00:43:27,190 --> 00:43:25,839

don't know how i could tell the

1287

00:43:28,950 --> 00:43:27,200

difference between being the only

1288

00:43:30,150 --> 00:43:28,960

conscious person or not being the only

1289

00:43:32,230 --> 00:43:30,160

conscious person

1290

00:43:34,550 --> 00:43:32,240

i mean i assume other people are

1291

00:43:35,829 --> 00:43:34,560

conscious just by analogy with myself

1292

00:43:37,910 --> 00:43:35,839

but i

1293

00:43:39,589 --> 00:43:37,920

i can't imagine any experiment that

1294

00:43:41,349 --> 00:43:39,599

could actually prove beyond doubt that

1295

00:43:42,470 --> 00:43:41,359

someone else was really conscious rather

1296

00:43:47,030 --> 00:43:42,480

than just a

1297

00:43:48,870 --> 00:43:47,040

running inside someone's brain

1298

00:43:50,390 --> 00:43:48,880

okay again it's this problem of what is

1299

00:43:52,470 --> 00:43:50,400

free will i

1300

00:43:53,990 --> 00:43:52,480

i can't think of any experiment that can

1301
00:43:57,270 --> 00:43:54,000
tell the difference between having free

1302
00:44:00,390 --> 00:43:57,280
will and not having free will okay

1303
00:44:01,270 --> 00:44:00,400
how about this i imagine that there is

1304
00:44:03,829 --> 00:44:01,280
no

1305
00:44:05,910 --> 00:44:03,839
experiment that can test whether you

1306
00:44:07,670 --> 00:44:05,920
love your wife or your wife loves you

1307
00:44:09,430 --> 00:44:07,680
yet i imagine also that the answer to

1308
00:44:11,109 --> 00:44:09,440
that matters to you

1309
00:44:13,349 --> 00:44:11,119
so in a similar well does it first of

1310
00:44:15,030 --> 00:44:13,359
all well it's it's a it's another these

1311
00:44:18,790 --> 00:44:15,040
terms it's really hard to

1312
00:44:20,550 --> 00:44:18,800
define i mean i'm i think this is this

1313
00:44:22,550 --> 00:44:20,560

is another question about my internal

1314

00:44:24,710 --> 00:44:22,560

state of mind which as i've noticed in

1315

00:44:26,470 --> 00:44:24,720

several of your other questions i a very

1316

00:44:28,550 --> 00:44:26,480

hard time figuring out what my internal

1317

00:44:33,510 --> 00:44:28,560

state of mind actually is

1318

00:44:36,470 --> 00:44:35,109

do you tend to think about yourself or

1319

00:44:37,750 --> 00:44:36,480

do you just tend to think outside

1320

00:44:40,069 --> 00:44:37,760

yourself

1321

00:44:41,750 --> 00:44:40,079

i i do sometimes think about myself and

1322

00:44:43,670 --> 00:44:41,760

the conclusion i tend to come to is that

1323

00:44:44,630 --> 00:44:43,680

i have absolutely no idea what is going

1324

00:44:46,790 --> 00:44:44,640

on i mean it's

1325

00:44:49,030 --> 00:44:46,800

it's it's a problem that i've that

1326

00:44:50,710 --> 00:44:49,040

completely baffles me

1327

00:44:52,390 --> 00:44:50,720

i mean i have no idea what is going on

1328

00:44:54,470 --> 00:44:52,400

in my own mind let alone what is going

1329

00:44:55,910 --> 00:44:54,480

on in other people's minds

1330

00:44:57,750 --> 00:44:55,920

so do you have any thoughts about

1331

00:45:01,190 --> 00:44:57,760

equivocal questions about the

1332

00:45:02,710 --> 00:45:01,200

hard problem of consciousness um

1333

00:45:04,950 --> 00:45:02,720

you have to remind me which which is the

1334

00:45:07,030 --> 00:45:04,960

hard problem i vaguely remember penrose

1335

00:45:08,550 --> 00:45:07,040

talking about this but i've

1336

00:45:10,470 --> 00:45:08,560

forgotten which is the easy problem

1337

00:45:12,069 --> 00:45:10,480

which is the hard problem the easy

1338

00:45:14,309 --> 00:45:12,079

problem are the correlates so for

1339

00:45:15,589 --> 00:45:14,319

example anger is associated with so and

1340

00:45:17,589 --> 00:45:15,599

so part of the brain

1341

00:45:19,190 --> 00:45:17,599

and a certain circuit the heart problem

1342

00:45:20,870 --> 00:45:19,200

is how is it at all that

1343

00:45:24,230 --> 00:45:20,880

consciousness that is experienced can

1344

00:45:27,670 --> 00:45:24,240

arise from material only

1345

00:45:29,270 --> 00:45:27,680

um yeah this th this is like all these

1346

00:45:32,630 --> 00:45:29,280

questions in

1347

00:45:33,829 --> 00:45:32,640

douglas hof starters books and again i

1348

00:45:35,829 --> 00:45:33,839

have no idea

1349

00:45:38,470 --> 00:45:35,839

we have all these experiments like like

1350

00:45:39,109 --> 00:45:38,480

suppose you simulate the brain by taking

1351
00:45:51,430 --> 00:45:39,119

a

1352
00:45:53,109 --> 00:45:51,440

conscious

1353
00:45:54,470 --> 00:45:53,119

and then you could go a step further and

1354
00:45:56,870 --> 00:45:54,480

you could

1355
00:45:58,309 --> 00:45:56,880

write a complete description of the

1356
00:46:00,470 --> 00:45:58,319

human brain and what it's doing on a

1357
00:46:03,670 --> 00:46:00,480

very big piece of paper

1358
00:46:06,309 --> 00:46:03,680

and is that piece of paper conscious and

1359
00:46:08,150 --> 00:46:06,319

you know if if you you know erase bits

1360
00:46:09,670 --> 00:46:08,160

of this piece of paper according to

1361
00:46:10,710 --> 00:46:09,680

certain rules they're simulating the

1362
00:46:13,270 --> 00:46:10,720

action of the brain

1363
00:46:14,950 --> 00:46:13,280

are is you know is is that piece of

1364

00:46:17,030 --> 00:46:14,960

paper with all these

1365

00:46:18,790 --> 00:46:17,040

things being erased repeatedly conscious

1366

00:46:21,190 --> 00:46:18,800

because it's you know in some sense it's

1367

00:46:23,589 --> 00:46:21,200

indistinguishable from a human brain

1368

00:46:25,670 --> 00:46:23,599

and on the other hand it seems utterly

1369

00:46:28,550 --> 00:46:25,680

ridiculous to claim it's conscious

1370

00:46:29,349 --> 00:46:28,560

i i have no idea how to resolve this

1371

00:46:30,230 --> 00:46:29,359

problem

1372

00:46:32,390 --> 00:46:30,240

what are some of your favorite

1373

00:46:35,910 --> 00:46:32,400

mathematicians and physicists

1374

00:46:37,910 --> 00:46:35,920

alive alive oh um

1375

00:46:39,190 --> 00:46:37,920

well i think the the one i like reading

1376

00:46:41,510 --> 00:46:39,200

most is probably jp

1377

00:46:43,589 --> 00:46:41,520

ser i mean i i don't work in his area

1378

00:46:45,990 --> 00:46:43,599

but he's so good at writing that

1379

00:46:47,430 --> 00:46:46,000

that i read almost you know i try and

1380

00:46:48,150 --> 00:46:47,440

read almost everything he's written

1381

00:46:50,230 --> 00:46:48,160

because he's saying

1382

00:46:51,670 --> 00:46:50,240

the number theorists explaining well

1383

00:46:52,790 --> 00:46:51,680

he's he's one of these really great

1384

00:46:56,150 --> 00:46:52,800

mathematicians who

1385

00:46:57,829 --> 00:46:56,160

moves around so he's a number theorist

1386

00:47:01,030 --> 00:46:57,839

he's also an algebraic geometry he's

1387

00:47:03,349 --> 00:47:01,040

also an algebraic apologist and he's

1388

00:47:04,790 --> 00:47:03,359

also done quite a few other things i

1389

00:47:06,550 --> 00:47:04,800

mean he's he's sort of one of the

1390

00:47:09,190 --> 00:47:06,560

closest things we have to a universal

1391

00:47:12,630 --> 00:47:09,200

mathematician what about terry tau

1392

00:47:13,670 --> 00:47:12,640

um yeah again um um i've been collecting

1393

00:47:15,910 --> 00:47:13,680

his books and

1394

00:47:17,430 --> 00:47:15,920

and and they're on my big pile of books

1395

00:47:18,150 --> 00:47:17,440

i really ought to get around to reading

1396

00:47:21,670 --> 00:47:18,160

some day

1397

00:47:23,190 --> 00:47:21,680

um and yeah he's

1398

00:47:24,950 --> 00:47:23,200

that that's interesting because he

1399

00:47:26,630 --> 00:47:24,960

thinks in such a different way from what

1400

00:47:30,549 --> 00:47:26,640

i do i mean he's an analyst

1401

00:47:32,150 --> 00:47:30,559

and um well again he's not just an

1402

00:47:33,990 --> 00:47:32,160

analyst he also does lots of things in

1403

00:47:35,910 --> 00:47:34,000

number theory and and so on but

1404

00:47:37,829 --> 00:47:35,920

and he's obviously thinking much more in

1405

00:47:39,670 --> 00:47:37,839

terms of inequalities and error

1406

00:47:43,030 --> 00:47:39,680

estimates and all the other things that

1407

00:47:45,109 --> 00:47:43,040

analysts do than i do and so i'm i'd say

1408

00:47:46,150 --> 00:47:45,119

much more towards the algebraic side

1409

00:47:48,390 --> 00:47:46,160

where i

1410

00:47:49,349 --> 00:47:48,400

do equalities and then sort of get a bit

1411

00:47:52,630 --> 00:47:49,359

nervous whenever

1412

00:47:55,190 --> 00:47:52,640

anybody writes down an inequality sign

1413

00:47:57,030 --> 00:47:55,200

what about physicists now uh i don't

1414

00:48:00,390 --> 00:47:57,040

really have favorite physicists

1415

00:48:01,910 --> 00:48:00,400

um i mean i i enjoy reading richard

1416

00:48:03,990 --> 00:48:01,920

feynman but that's

1417

00:48:05,829 --> 00:48:04,000

that's that's largely because of his

1418

00:48:09,630 --> 00:48:05,839

popular books rather than because of his

1419

00:48:15,190 --> 00:48:12,390

[Music]

1420

00:48:17,270 --> 00:48:15,200

who else i read you know stephen

1421

00:48:18,630 --> 00:48:17,280

weinberg has some rather nice books on

1422

00:48:22,470 --> 00:48:18,640

quantum field theory

1423

00:48:24,150 --> 00:48:22,480

and yeah i i i don't spend so much time

1424

00:48:25,430 --> 00:48:24,160

on physics really

1425

00:48:26,870 --> 00:48:25,440

what are your thoughts on ed whitten

1426

00:48:27,349 --> 00:48:26,880

have you collaborated with him or met

1427

00:48:31,750 --> 00:48:27,359

him

1428

00:48:34,069 --> 00:48:31,760

terrifying he he produced these you know

1429

00:48:36,309 --> 00:48:34,079

fantastically brilliant papers about one

1430

00:48:38,470 --> 00:48:36,319

a month or something and i

1431

00:48:39,910 --> 00:48:38,480

i don't know i have no idea how he has

1432

00:48:43,349 --> 00:48:39,920

the energy to do this

1433

00:48:45,589 --> 00:48:43,359

and you know it's a stream of endless

1434

00:48:49,030 --> 00:48:45,599

good ideas that he comes up with i mean

1435

00:48:51,190 --> 00:48:49,040

he i mean he he he came up with these

1436

00:48:53,430 --> 00:48:51,200

cyborg written in vance and they they

1437

00:48:55,750 --> 00:48:53,440

were almost a sort of minor side effect

1438

00:48:57,589 --> 00:48:55,760

of something else he was thinking on and

1439

00:49:00,069 --> 00:48:57,599

you know they revolutionized some area

1440

00:49:03,270 --> 00:49:00,079

in mathematics that

1441

00:49:05,190 --> 00:49:03,280

you know he he really

1442

00:49:07,670 --> 00:49:05,200

had almost had nothing to do with before

1443

00:49:09,670 --> 00:49:07,680

that's you know he was just sort of

1444

00:49:11,910 --> 00:49:09,680

revolutionizing the area of mathematics

1445

00:49:13,270 --> 00:49:11,920

just as a casual side effect of

1446

00:49:14,710 --> 00:49:13,280

something else he was doing

1447

00:49:16,309 --> 00:49:14,720

let's get to the monster group what are

1448

00:49:16,710 --> 00:49:16,319

some of the applications of the monster

1449

00:49:20,150 --> 00:49:16,720

group

1450

00:49:23,829 --> 00:49:20,160

to physics they're all intended

1451

00:49:25,910 --> 00:49:23,839

are there conjectures um well

1452

00:49:27,270 --> 00:49:25,920

there there are some there's been some

1453

00:49:30,870 --> 00:49:27,280

speculation i mean

1454

00:49:32,710 --> 00:49:30,880

ed whitton for example has some

1455

00:49:34,069 --> 00:49:32,720

um speculation about a connection

1456

00:49:35,670 --> 00:49:34,079

between the monster and some sort of

1457

00:49:37,349 --> 00:49:35,680

gravity theory

1458

00:49:39,510 --> 00:49:37,359

and that the mathematics behind the

1459

00:49:41,349 --> 00:49:39,520

monsters is quite similar to a lot of

1460

00:49:44,790 --> 00:49:41,359

mathematics that turns up in string

1461

00:49:47,910 --> 00:49:44,800

theory so you can speculate that there's

1462

00:49:49,910 --> 00:49:47,920

a connection but no one has ever found

1463

00:49:51,349 --> 00:49:49,920

any sign that the monsters anything to

1464

00:49:53,430 --> 00:49:51,359

do with you know real

1465

00:49:55,109 --> 00:49:53,440

everyday four-dimensional physics there

1466

00:49:56,309 --> 00:49:55,119

are some people who try to build physics

1467

00:49:58,470 --> 00:49:56,319

off of the e8

1468

00:49:59,670 --> 00:49:58,480

and what has a dimension in eight has an

1469

00:50:02,150 --> 00:49:59,680

echo in 24

1470

00:50:03,030 --> 00:50:02,160

and then 24 is somehow associated with a

1471

00:50:05,430 --> 00:50:03,040

monster

1472

00:50:07,829 --> 00:50:05,440

so yeah i'm wondering can one base

1473

00:50:12,150 --> 00:50:07,839

physics off of the monster group

1474

00:50:14,390 --> 00:50:12,160

um i wouldn't

1475

00:50:15,510 --> 00:50:14,400

um i would write that off as a really

1476

00:50:16,790 --> 00:50:15,520

crazy idea

1477

00:50:18,790 --> 00:50:16,800

i'm not saying it's wrong i'm just

1478

00:50:20,309 --> 00:50:18,800

saying it's really crazy

1479

00:50:21,990 --> 00:50:20,319

um i mean it'd be really nice if the

1480

00:50:23,670 --> 00:50:22,000

monster group did turn up in physics

1481

00:50:24,630 --> 00:50:23,680

somewhere but as i said there's there's

1482

00:50:26,870 --> 00:50:24,640

no

1483

00:50:28,950 --> 00:50:26,880

realistic sign of this yet apart from

1484

00:50:32,870 --> 00:50:28,960

the fact that both the monster and

1485

00:50:33,910 --> 00:50:32,880

string theory use that you use similar

1486

00:50:35,670 --> 00:50:33,920

ideas

1487

00:50:37,990 --> 00:50:35,680

for people watching just so you know

1488

00:50:41,270 --> 00:50:38,000

professor portraits has a

1489

00:50:42,710 --> 00:50:41,280

great youtube series on teaching

1490

00:50:44,309 --> 00:50:42,720

graduate level mathematics and i

1491

00:50:45,829 --> 00:50:44,319

recommend you check that out do you

1492

00:50:48,390 --> 00:50:45,839

enjoy teaching

1493

00:50:50,230 --> 00:50:48,400

is it just your connotation it's fun

1494

00:50:53,349 --> 00:50:50,240

making these videos except it's

1495

00:50:56,309 --> 00:50:53,359

it's also kind of stressful because

1496

00:50:56,710 --> 00:50:56,319

i mean it's i hadn't realized just how

1497

00:50:59,829 --> 00:50:56,720

many

1498

00:51:01,030 --> 00:50:59,839

errors i made in lectures um you know

1499

00:51:03,349 --> 00:51:01,040

you're lecturing and

1500

00:51:04,150 --> 00:51:03,359

you don't notice anything wrong and then

1501

00:51:05,750 --> 00:51:04,160

suddenly

1502

00:51:07,589 --> 00:51:05,760

when you put the youtube up people

1503

00:51:08,150 --> 00:51:07,599

pointing out all these embarrassingly

1504

00:51:11,750 --> 00:51:08,160

stupid

1505

00:51:13,829 --> 00:51:11,760

misprints you made and

1506

00:51:15,430 --> 00:51:13,839

you know i i i guess i should just feel

1507

00:51:16,950 --> 00:51:15,440

relieved that i'm not a you know i

1508

00:51:18,950 --> 00:51:16,960

sometimes think well it's

1509

00:51:20,309 --> 00:51:18,960

thank goodness i'm not a doctor or a cop

1510

00:51:22,150 --> 00:51:20,319

or something because you know if a

1511

00:51:23,910 --> 00:51:22,160

doctor or a cop makes a mistake

1512

00:51:26,390 --> 00:51:23,920

you know there's someone dead and there

1513

00:51:26,870 --> 00:51:26,400

are headlines and committees of inquiry

1514

00:51:28,710 --> 00:51:26,880

and

1515

00:51:30,710 --> 00:51:28,720

when i make an embarrassing mistake i

1516

00:51:31,589 --> 00:51:30,720

get this polite note from a youtube

1517

00:51:33,109 --> 00:51:31,599

comment so i

1518

00:51:34,790 --> 00:51:33,119

maybe i shouldn't complain too much

1519

00:51:36,630 --> 00:51:34,800

about it you mentioned

1520

00:51:38,150 --> 00:51:36,640

that innovations coming from outside the

1521

00:51:41,030 --> 00:51:38,160

field of academia

1522

00:51:43,030 --> 00:51:41,040

for math in particular is rare unlike

1523

00:51:44,470 --> 00:51:43,040

the past which was

1524

00:51:46,630 --> 00:51:44,480

you gave some examples for matt and

1525

00:51:48,549 --> 00:51:46,640

kaylee who were lawyers

1526
00:51:50,470 --> 00:51:48,559
and i'm wondering is this still true

1527
00:51:51,829 --> 00:51:50,480
today as far as i know

1528
00:51:53,349 --> 00:51:51,839
you mentioned one of the reasons is that

1529
00:51:54,069 --> 00:51:53,359
it's easier to get a position in

1530
00:51:57,109 --> 00:51:54,079
academia

1531
00:51:59,270 --> 00:51:57,119
but i don't know if that's true today

1532
00:52:01,349 --> 00:51:59,280
well unless you're a postdoc it's very

1533
00:52:02,710 --> 00:52:01,359
much true compared to now compared to a

1534
00:52:04,309 --> 00:52:02,720
few hundred years ago when there

1535
00:52:06,069 --> 00:52:04,319
basically weren't any positions for

1536
00:52:09,190 --> 00:52:06,079
mathematicians in academia

1537
00:52:10,870 --> 00:52:09,200
maybe one or two in the world the the

1538
00:52:12,710 --> 00:52:10,880

other big problem is

1539

00:52:15,109 --> 00:52:12,720

all the easy stuff in mathematics and

1540

00:52:18,309 --> 00:52:15,119

physics has been done

1541

00:52:20,710 --> 00:52:18,319

so people like firma when they started

1542

00:52:24,470 --> 00:52:20,720

doing mathematics said that there were

1543

00:52:26,710 --> 00:52:24,480

whole loads of things they could do

1544

00:52:28,549 --> 00:52:26,720

which well that they were difficult for

1545

00:52:29,910 --> 00:52:28,559

the time but nowadays they count as easy

1546

00:52:31,910 --> 00:52:29,920

whereas

1547

00:52:33,190 --> 00:52:31,920

if someone was starting from outside

1548

00:52:35,109 --> 00:52:33,200

trying to do mathematics now it'd be

1549

00:52:37,990 --> 00:52:35,119

incredibly difficult because

1550

00:52:40,470 --> 00:52:38,000

anything you can think of in less than

1551
00:52:44,309 --> 00:52:40,480
several years study someone has already

1552
00:52:45,589 --> 00:52:44,319
thought of it so it's it's partly that

1553
00:52:48,470 --> 00:52:45,599
there are

1554
00:52:50,150 --> 00:52:48,480
i mean i mean people coming from outside

1555
00:52:51,270 --> 00:52:50,160
doing something big in mathematics has

1556
00:52:53,270 --> 00:52:51,280
become

1557
00:52:54,870 --> 00:52:53,280
very rare because it's so difficult to

1558
00:52:58,870 --> 00:52:54,880
find

1559
00:53:00,549 --> 00:52:58,880
any problem that an outsider can do

1560
00:53:02,549 --> 00:53:00,559
what advice do you have for outsiders

1561
00:53:04,710 --> 00:53:02,559
who want to contribute to math or at

1562
00:53:05,990 --> 00:53:04,720
least study it at the graduate phd level

1563
00:53:08,549 --> 00:53:06,000

but they're on their own it's the

1564

00:53:10,230 --> 00:53:08,559

pandemic they don't have peers

1565

00:53:12,150 --> 00:53:10,240

much like yourself you don't collaborate

1566

00:53:13,910 --> 00:53:12,160

so what advice do you have for them

1567

00:53:15,349 --> 00:53:13,920

if you really want to contribute

1568

00:53:16,390 --> 00:53:15,359

something new you need to find a

1569

00:53:19,430 --> 00:53:16,400

relatively new

1570

00:53:21,349 --> 00:53:19,440

area in mathematics um

1571

00:53:23,349 --> 00:53:21,359

so i mean every now and then that

1572

00:53:24,230 --> 00:53:23,359

someone has a new idea that breaks open

1573

00:53:26,630 --> 00:53:24,240

a new area

1574

00:53:28,549 --> 00:53:26,640

and then you know it's it's like you

1575

00:53:31,670 --> 00:53:28,559

know there's this

1576

00:53:32,870 --> 00:53:31,680

um dead whale theory you know if you're

1577

00:53:34,390 --> 00:53:32,880

at the bottom of an ocean there's

1578

00:53:36,390 --> 00:53:34,400

usually nothing to eat but every now and

1579

00:53:38,230 --> 00:53:36,400

then there's a dead whale comes down and

1580

00:53:40,390 --> 00:53:38,240

everybody goes frantic eating it

1581

00:53:42,230 --> 00:53:40,400

and every now and then there's a really

1582

00:53:44,150 --> 00:53:42,240

new area in mathematics and if you can

1583

00:53:45,670 --> 00:53:44,160

spot one of those and get in on it then

1584

00:53:48,950 --> 00:53:45,680

there's a lot to do

1585

00:53:49,670 --> 00:53:48,960

a typical example a few years ago with

1586

00:53:51,829 --> 00:53:49,680

things like

1587

00:53:55,589 --> 00:53:51,839

fractals and chaos became really big

1588

00:54:01,750 --> 00:53:59,109

it's very hard to suggest new areas

1589

00:54:03,430 --> 00:54:01,760

because if i knew about them then

1590

00:54:06,069 --> 00:54:03,440

i'd probably already be working in it or

1591

00:54:08,309 --> 00:54:06,079

something um

1592

00:54:09,349 --> 00:54:08,319

yeah there's one thing i was thinking of

1593

00:54:14,470 --> 00:54:09,359

that

1594

00:54:16,230 --> 00:54:14,480

none people are not mathematicians might

1595

00:54:19,270 --> 00:54:16,240

be able to contribute to and that's

1596

00:54:22,470 --> 00:54:19,280

um artificial intelligence

1597

00:54:24,870 --> 00:54:22,480

doing mathematics i mean you know

1598

00:54:26,309 --> 00:54:24,880

um so google came up with this

1599

00:54:27,510 --> 00:54:26,319

artificial intelligence program that

1600

00:54:29,510 --> 00:54:27,520

could play go or chess

1601
00:54:31,190 --> 00:54:29,520
very well and i'm pretty sure the people

1602
00:54:32,950 --> 00:54:31,200
at google programming this were not

1603
00:54:34,630 --> 00:54:32,960
expert go or chess players

1604
00:54:36,230 --> 00:54:34,640
they they were what they were really

1605
00:54:38,870 --> 00:54:36,240
good at was building an artificial

1606
00:54:41,510 --> 00:54:38,880
intelligence system and

1607
00:54:42,870 --> 00:54:41,520
sooner or later artificial intelligence

1608
00:54:45,349 --> 00:54:42,880
is probably going to get good enough to

1609
00:54:49,109 --> 00:54:45,359
do serious mathematics

1610
00:54:52,470 --> 00:54:49,119
um so that might be one thing to look at

1611
00:54:54,630 --> 00:54:52,480
if you're an outsider um you know

1612
00:54:56,470 --> 00:54:54,640
get into artificial intelligence doing

1613
00:54:57,430 --> 00:54:56,480

mathematics i think there are not so

1614

00:54:59,670 --> 00:54:57,440

many

1615

00:55:00,950 --> 00:54:59,680

pure mathematicians looking at that now

1616

00:55:03,030 --> 00:55:00,960

and

1617

00:55:05,349 --> 00:55:03,040

in a few years it might take off quite

1618

00:55:06,950 --> 00:55:05,359

suddenly so in some sense

1619

00:55:08,470 --> 00:55:06,960

let's say 30 40 years from now the

1620

00:55:09,829 --> 00:55:08,480

computers will be better than us at

1621

00:55:11,829 --> 00:55:09,839

doing mathematics so why don't you be

1622

00:55:13,910 --> 00:55:11,839

the puppet master behind the computer

1623

00:55:14,950 --> 00:55:13,920

if you want to help the innovation yeah

1624

00:55:16,230 --> 00:55:14,960

yeah exactly

1625

00:55:18,230 --> 00:55:16,240

at some point did you ever feel like

1626
00:55:20,230 --> 00:55:18,240
math and physics wasn't for you either

1627
00:55:21,990 --> 00:55:20,240
because of its difficulty or for some

1628
00:55:25,829 --> 00:55:22,000
other reason

1629
00:55:29,430 --> 00:55:25,839
um no not really

1630
00:55:30,950 --> 00:55:29,440
um it sort of never never seriously

1631
00:55:32,069 --> 00:55:30,960
occurred to me to do anything other than

1632
00:55:34,309 --> 00:55:32,079
mathematics i mean

1633
00:55:35,589 --> 00:55:34,319
maybe when i was six i you know thought

1634
00:55:37,349 --> 00:55:35,599
it'd be fun to be a

1635
00:55:40,390 --> 00:55:37,359
fighter pilot or something but apart

1636
00:55:41,750 --> 00:55:40,400
from that it's

1637
00:55:44,069 --> 00:55:41,760
never seriously considered anything

1638
00:55:47,270 --> 00:55:44,079

other than mathematics or possibly

1639

00:55:48,390 --> 00:55:47,280

computing as an emergency backup

1640

00:55:51,589 --> 00:55:48,400

what are your thoughts on the many

1641

00:55:55,349 --> 00:55:54,549

well like i said it's you have all these

1642

00:55:57,510 --> 00:55:55,359

phrases

1643

00:55:59,030 --> 00:55:57,520

like you know maybe the maybe there are

1644

00:56:02,230 --> 00:55:59,040

many worlds maybe there's a

1645

00:56:05,910 --> 00:56:02,240

we're a computer simulation maybe we're

1646

00:56:08,950 --> 00:56:05,920

uh cellular automaton that

1647

00:56:10,309 --> 00:56:08,960

they don't seem to mean anything um so

1648

00:56:12,150 --> 00:56:10,319

what's the difference between a many

1649

00:56:13,910 --> 00:56:12,160

worlds interpretation and a non-many

1650

00:56:16,630 --> 00:56:13,920

worlds interpretation well there doesn't

1651

00:56:18,390 --> 00:56:16,640

seem to be any difference

1652

00:56:19,750 --> 00:56:18,400

okay i'm gonna get to some audience

1653

00:56:22,390 --> 00:56:19,760

questions from

1654

00:56:24,150 --> 00:56:22,400

reddit i think that modern geometry is

1655

00:56:25,589 --> 00:56:24,160

overly complicated as in

1656

00:56:27,829 --> 00:56:25,599

if you look at john lee's introduction

1657

00:56:28,470 --> 00:56:27,839

to smooth manifolds you'll find that it

1658

00:56:29,990 --> 00:56:28,480

has

1659

00:56:32,309 --> 00:56:30,000

plenty of little lemmas and theorem

1660

00:56:33,829 --> 00:56:32,319

theorems that say very little

1661

00:56:35,430 --> 00:56:33,839

the content is little but they're

1662

00:56:37,670 --> 00:56:35,440

elaborate proofs

1663

00:56:39,589 --> 00:56:37,680

and i'm wondering if this inadequacy is

1664

00:56:40,549 --> 00:56:39,599

due to basing the foundations of math on

1665

00:56:42,870 --> 00:56:40,559

set theory

1666

00:56:44,150 --> 00:56:42,880

leading to very cumbersome frameworks

1667

00:56:45,750 --> 00:56:44,160

for geometry

1668

00:56:48,069 --> 00:56:45,760

do you sometimes feel that there should

1669

00:56:50,870 --> 00:56:48,079

be a way to base mathematics

1670

00:56:54,549 --> 00:56:50,880

off of some alternate framework some

1671

00:56:57,349 --> 00:56:54,559

topological geometric consideration

1672

00:56:58,069 --> 00:56:57,359

that's less cumbersome well there have

1673

00:57:00,549 --> 00:56:58,079

been

1674

00:57:01,910 --> 00:57:00,559

endless attempts to do this i mean what

1675

00:57:04,549 --> 00:57:01,920

you have to remember is that

1676

00:57:06,230 --> 00:57:04,559

set theory didn't become the well

1677

00:57:08,390 --> 00:57:06,240

practical foundations and mathematics

1678

00:57:09,990 --> 00:57:08,400

just because someone decreed it

1679

00:57:11,670 --> 00:57:10,000

um what happened early in the 20th

1680

00:57:13,670 --> 00:57:11,680

century people were trying

1681

00:57:15,670 --> 00:57:13,680

dozens and dozens and dozens of

1682

00:57:16,789 --> 00:57:15,680

different attempts to have foundations

1683

00:57:18,710 --> 00:57:16,799

and mathematics i mean

1684

00:57:19,910 --> 00:57:18,720

the principia mathematica of russell and

1685

00:57:22,950 --> 00:57:19,920

white's head

1686

00:57:26,230 --> 00:57:22,960

lambda calculus um

1687

00:57:27,430 --> 00:57:26,240

and um quine or however you pronounce

1688

00:57:29,829 --> 00:57:27,440

his name came up with

1689

00:57:31,510 --> 00:57:29,839

another foundation of mathematics and

1690

00:57:34,069 --> 00:57:31,520

the reason we use set theory because it

1691

00:57:34,950 --> 00:57:34,079

was one out as being the most convenient

1692

00:57:36,470 --> 00:57:34,960

one and

1693

00:57:38,309 --> 00:57:36,480

people are trying all sorts of things

1694

00:57:40,069 --> 00:57:38,319

these days based on type theory or

1695

00:57:43,829 --> 00:57:40,079

category theory

1696

00:57:45,510 --> 00:57:43,839

and again none of them have really taken

1697

00:57:48,870 --> 00:57:45,520

over from set theory so

1698

00:57:50,470 --> 00:57:48,880

so set theory as sort of one by sort of

1699

00:57:53,030 --> 00:57:50,480

evolutionary process

1700

00:57:54,950 --> 00:57:53,040

people keep trying to modify things and

1701

00:57:57,270 --> 00:57:54,960

taking the fittest one that

1702

00:57:59,030 --> 00:57:57,280

that survives best and set theory is the

1703

00:58:02,630 --> 00:57:59,040

one that has won out

1704

00:58:05,829 --> 00:58:02,640

so when you say set theory is clumsy and

1705

00:58:07,510 --> 00:58:05,839

lots of problems to it yes that's true

1706

00:58:10,390 --> 00:58:07,520

but the trouble is everything else is

1707

00:58:13,270 --> 00:58:10,400

even worse problems

1708

00:58:14,230 --> 00:58:13,280

um i figure that when computers start

1709

00:58:16,150 --> 00:58:14,240

doing mathematics

1710

00:58:17,670 --> 00:58:16,160

that it may be that they won't use set

1711

00:58:19,990 --> 00:58:17,680

theory because

1712

00:58:21,829 --> 00:58:20,000

some forms of type theory or something a

1713

00:58:23,270 --> 00:58:21,839

little bit more computational and set

1714

00:58:26,309 --> 00:58:23,280

theory maybe a bit better

1715

00:58:28,309 --> 00:58:26,319

um and in fact there there are

1716

00:58:29,910 --> 00:58:28,319

about a dozen or so different attempts

1717

00:58:32,309 --> 00:58:29,920

to

1718

00:58:34,950 --> 00:58:32,319

find a good foundation for computers

1719

00:58:37,349 --> 00:58:34,960

doing mathematics and most of them

1720

00:58:39,190 --> 00:58:37,359

um don't seem to use set theory directly

1721

00:58:41,030 --> 00:58:39,200

but again what we're seeing is an

1722

00:58:42,309 --> 00:58:41,040

evolutionary process people are going to

1723

00:58:45,270 --> 00:58:42,319

try out

1724

00:58:46,870 --> 00:58:45,280

all these different approaches and

1725

00:58:49,270 --> 00:58:46,880

probably one of them will turn out to be

1726

00:58:50,870 --> 00:58:49,280

better than the others and take over

1727

00:58:52,870 --> 00:58:50,880

i find that when i talk to category

1728

00:58:54,069 --> 00:58:52,880

theorists they say the foundation should

1729

00:58:56,710 --> 00:58:54,079

be category

1730

00:58:58,710 --> 00:58:56,720

oh that's nonsense category theory is a

1731

00:59:00,230 --> 00:58:58,720

useful bookkeeping device but the idea

1732

00:59:00,549 --> 00:59:00,240

that it's the ultimate foundation is

1733

00:59:02,789 --> 00:59:00,559

just

1734

00:59:03,910 --> 00:59:02,799

silly i mean it's like you know finite

1735

00:59:05,510 --> 00:59:03,920

simple group theorists saying the

1736

00:59:07,670 --> 00:59:05,520

ultimate foundation should be finite

1737

00:59:10,069 --> 00:59:07,680

simple group theory or whatever

1738

00:59:11,990 --> 00:59:10,079

um the problem is category is just not a

1739

00:59:13,910 --> 00:59:12,000

primitive concept

1740

00:59:15,750 --> 00:59:13,920

um you can write down axioms for a

1741

00:59:17,670 --> 00:59:15,760

category but there's

1742

00:59:19,430 --> 00:59:17,680

you know it's you know i mean maybe you

1743

00:59:21,589 --> 00:59:19,440

want to base mathematics on say an

1744

00:59:22,870 --> 00:59:21,599

elementary topos which is a special sort

1745

00:59:24,950 --> 00:59:22,880

of category

1746

00:59:27,109 --> 00:59:24,960

well fine you can develop mathematics

1747

00:59:27,910 --> 00:59:27,119

inside an elementary topos that's no

1748

00:59:29,670 --> 00:59:27,920

problem

1749

00:59:30,950 --> 00:59:29,680

the trouble is this gives you no

1750

00:59:32,630 --> 00:59:30,960

explanation for why

1751

00:59:34,549 --> 00:59:32,640

the actions for an elementary topper

1752

00:59:36,950 --> 00:59:34,559

should be consistent

1753

00:59:38,950 --> 00:59:36,960

um set theory at least makes a sort of

1754

00:59:41,030 --> 00:59:38,960

gesture about trying to explain why the

1755

00:59:41,829 --> 00:59:41,040

axioms of set theory are consistent i

1756

00:59:43,510 --> 00:59:41,839

mean

1757

00:59:45,030 --> 00:59:43,520

i don't think it's a very successful

1758

00:59:46,470 --> 00:59:45,040

explanation but at least they sort of

1759

00:59:51,190 --> 00:59:46,480

make a

1760

00:59:54,150 --> 00:59:51,200

token attempt

1761

00:59:55,829 --> 00:59:54,160

um trying to claim the foundations of

1762

00:59:58,630 --> 00:59:55,839

mathematics a category theory there's

1763

01:00:01,589 --> 00:59:58,640

there's just no attempt to explain why

1764

01:00:03,589 --> 01:00:01,599

the axiom should be true or consistent

1765

01:00:06,630 --> 01:00:03,599

or whatever

1766

01:00:08,069 --> 01:00:06,640

this is a similar question i have always

1767

01:00:09,510 --> 01:00:08,079

been interested in seeing whether we

1768

01:00:11,510 --> 01:00:09,520

could develop an all-encompassing

1769

01:00:12,870 --> 01:00:11,520

framework despite decades of seeing a

1770

01:00:14,870 --> 01:00:12,880

proliferation of different set

1771

01:00:17,030 --> 01:00:14,880

theories with all sorts of independent

1772

01:00:19,670 --> 01:00:17,040

results i know hugh woodland

1773

01:00:20,630 --> 01:00:19,680

or hugh wooden has been working on

1774

01:00:25,430 --> 01:00:20,640

ultimate I

1775

01:00:28,789 --> 01:00:25,440

others say pluralism is here to stay

1776

01:00:30,950 --> 01:00:28,799

people like joel david hampkins

1777

01:00:32,870 --> 01:00:30,960

who is a mathematical platonist what are

1778

01:00:34,870 --> 01:00:32,880

your thoughts on this subject

1779

01:00:35,910 --> 01:00:34,880

do you think mathematicians like hugh

1780

01:00:38,230 --> 01:00:35,920

wooden and

1781

01:00:40,069 --> 01:00:38,240

peter culner may find success in

1782

01:00:41,109 --> 01:00:40,079

developing an ultimate canonical model

1783

01:00:43,109 --> 01:00:41,119

of set theory

1784

01:00:44,549 --> 01:00:43,119

or would you more closely align yourself

1785

01:00:46,390 --> 01:00:44,559

with the multiverse view

1786

01:00:48,150 --> 01:00:46,400

of set theory that hampkins advocates

1787

01:00:50,390 --> 01:00:48,160

for i think

1788

01:00:51,910 --> 01:00:50,400

well my views on this change every month

1789

01:00:55,910 --> 01:00:51,920

or every year or so so

1790

01:00:56,150 --> 01:00:55,920

the current views is that my impression

1791

01:00:59,349 --> 01:00:56,160

is

1792

01:01:00,069 --> 01:00:59,359

different models of set theory and

1793

01:01:02,950 --> 01:01:00,079

there's no

1794

01:01:05,030 --> 01:01:02,960

ultimate model um in in some sense as a

1795

01:01:05,829 --> 01:01:05,040

consequence of godel's incompleteness

1796

01:01:07,829 --> 01:01:05,839

sim there's no

1797

01:01:09,349 --> 01:01:07,839

ultimate model of all sets that the best

1798

01:01:12,710 --> 01:01:09,359

we can do is have a

1799

01:01:14,870 --> 01:01:12,720

hierarchy of increasingly powerful

1800

01:01:17,910 --> 01:01:14,880

models or systems of set theory

1801

01:01:20,870 --> 01:01:17,920

so you know you can start off with say

1802

01:01:22,390 --> 01:01:20,880

zermlo set theory might be you know

1803

01:01:24,150 --> 01:01:22,400

somewhere near the bottom and then

1804

01:01:25,829 --> 01:01:24,160

above that you can have zermalo frenkel

1805

01:01:26,710 --> 01:01:25,839

set there which is a more powerful model

1806

01:01:30,069 --> 01:01:26,720

and then you can

1807

01:01:33,589 --> 01:01:30,079

start adding in your favorite um

1808

01:01:35,589 --> 01:01:33,599

your your favorite large cardinal axioms

1809

01:01:37,190 --> 01:01:35,599

and it just doesn't seem to be an

1810

01:01:39,030 --> 01:01:37,200

ultimate model

1811

01:01:40,390 --> 01:01:39,040

um and i think it's unlikely that it

1812

01:01:43,109 --> 01:01:40,400

will be in fact if there was an

1813

01:01:43,510 --> 01:01:43,119

ultimate model then you could just you

1814

01:01:45,270 --> 01:01:43,520

know

1815

01:01:46,870 --> 01:01:45,280

hit it with gerdell's theorem and point

1816

01:01:48,789 --> 01:01:46,880

out there's an even bigger model that

1817

01:01:51,109 --> 01:01:48,799

proves the consistency of your so-called

1818

01:01:54,549 --> 01:01:51,119

ultimate model

1819

01:01:57,670 --> 01:01:54,559

um you you may be able to find a sort of

1820

01:02:00,309 --> 01:01:57,680

ultimate convenient model that can do

1821

01:02:01,029 --> 01:02:00,319

everything we can think of at the moment

1822

01:02:02,789 --> 01:02:01,039

um

1823

01:02:05,349 --> 01:02:02,799

but i mean in some sense that's what

1824

01:02:07,270 --> 01:02:05,359

zermelo frankel set theory is it's

1825

01:02:08,789 --> 01:02:07,280

it's i don't think anybody claims that

1826

01:02:10,309 --> 01:02:08,799

zermelo franco's set theory is an

1827

01:02:12,390 --> 01:02:10,319

ultimate model but it's

1828

01:02:13,990 --> 01:02:12,400

it's enough to do almost everything we

1829

01:02:15,910 --> 01:02:14,000

need to in mathematics so it's a very

1830

01:02:17,430 --> 01:02:15,920

convenient one

1831

01:02:19,270 --> 01:02:17,440

you said that your views on this change

1832

01:02:20,950 --> 01:02:19,280

month by month or year by year

1833

01:02:22,470 --> 01:02:20,960

so what was it before and why did you

1834

01:02:24,150 --> 01:02:22,480

change it i don't know i sometimes

1835

01:02:26,630 --> 01:02:24,160

thought that

1836

01:02:27,750 --> 01:02:26,640

you know you can it can oscillate

1837

01:02:29,910 --> 01:02:27,760

between

1838

01:02:31,430 --> 01:02:29,920

finitis mathematics where you deny

1839

01:02:33,349 --> 01:02:31,440

everything that can't be expressed in

1840

01:02:35,270 --> 01:02:33,359

terms of computation and

1841

01:02:36,789 --> 01:02:35,280

you can go from there all the way to

1842

01:02:38,950 --> 01:02:36,799

platonism where you

1843

01:02:40,470 --> 01:02:38,960

claim that there is a single ultimate

1844

01:02:42,630 --> 01:02:40,480

universe of all sets

1845

01:02:44,309 --> 01:02:42,640

and there are all sorts of intermediate

1846

01:02:45,910 --> 01:02:44,319

points and i sort of float up and down

1847

01:02:47,510 --> 01:02:45,920

this depending on

1848

01:02:49,910 --> 01:02:47,520

i don't know depending on my mood or

1849

01:02:51,430 --> 01:02:49,920

what i've been thinking about recently

1850

01:02:53,670 --> 01:02:51,440

so recently or currently what do you

1851

01:02:54,630 --> 01:02:53,680

think of finite you called it finite

1852

01:02:56,230 --> 01:02:54,640

as far as i know it's called

1853

01:02:57,109 --> 01:02:56,240

intuitionist logic the computational

1854

01:03:00,470 --> 01:02:57,119

model

1855

01:03:03,510 --> 01:03:00,480

um that that has a lot going

1856

01:03:05,109 --> 01:03:03,520

for it um basically it's especially if

1857

01:03:07,029 --> 01:03:05,119

you're trying to do mathematics on a

1858

01:03:09,510 --> 01:03:07,039

computer because of course

1859

01:03:11,190 --> 01:03:09,520

a computational based foundations of

1860

01:03:12,230 --> 01:03:11,200

mathematics are particularly convenient

1861

01:03:13,990 --> 01:03:12,240

if you're actually trying to do

1862

01:03:17,349 --> 01:03:14,000

computations

1863

01:03:19,430 --> 01:03:17,359

um i mean you know computers can't

1864

01:03:20,950 --> 01:03:19,440

directly manipulate sets in the way that

1865

01:03:24,549 --> 01:03:20,960

they can directly manipulate

1866

01:03:26,789 --> 01:03:24,559

integers um the only trouble with the

1867

01:03:28,870 --> 01:03:26,799

finitistic foundations and mathematics

1868

01:03:31,190 --> 01:03:28,880

is they're very restrictive and it's

1869

01:03:33,109 --> 01:03:31,200

it's really hard to do most mathematics

1870

01:03:36,390 --> 01:03:33,119

in them i mean

1871

01:03:37,750 --> 01:03:36,400

it's sort of what the analogy is like um

1872

01:03:39,430 --> 01:03:37,760

you know it's one of these religious

1873

01:03:41,190 --> 01:03:39,440

sets i think someone once said it's a

1874

01:03:43,510 --> 01:03:41,200

bit like the shakers who

1875

01:03:45,430 --> 01:03:43,520

who built really sturdy barns but didn't

1876

01:03:47,029 --> 01:03:45,440

have offspring and and fine artist

1877

01:03:50,069 --> 01:03:47,039

mathematics is like that it's

1878

01:03:52,150 --> 01:03:50,079

it's really solid and

1879

01:03:53,829 --> 01:03:52,160

absolutely solid foundation but there's

1880

01:03:57,510 --> 01:03:53,839

it's it's difficult to do anything

1881

01:04:02,630 --> 01:04:00,150

i mean i mean if if you look at any

1882

01:04:05,029 --> 01:04:02,640

almost any piece of

1883

01:04:06,150 --> 01:04:05,039

mathematics for instance if you look at

1884

01:04:07,750 --> 01:04:06,160

say

1885

01:04:10,470 --> 01:04:07,760

why is this proof of firma's last

1886

01:04:12,309 --> 01:04:10,480

theorem okay fermi's last theorem makes

1887

01:04:15,349 --> 01:04:12,319

perfect good sense to a constructive

1888

01:04:18,549 --> 01:04:15,359

fine artist mathematician but

1889

01:04:20,870 --> 01:04:18,559

trying to encode wires as proof in

1890

01:04:22,549 --> 01:04:20,880

finitis terms well it would probably be

1891

01:04:25,029 --> 01:04:22,559

possible but it would be a real

1892

01:04:27,270 --> 01:04:25,039

nightmare to do i mean it would it would

1893

01:04:29,349 --> 01:04:27,280

take years and years of really boring

1894

01:04:30,549 --> 01:04:29,359

tedious work even if you could actually

1895

01:04:34,069 --> 01:04:30,559

do it

1896

01:04:35,990 --> 01:04:34,079

ariane raj asks can people after 40s

1897

01:04:37,109 --> 01:04:36,000

learn mathematics up to an advanced

1898

01:04:38,950 --> 01:04:37,119

level now let's

1899

01:04:40,470 --> 01:04:38,960

break that down i don't believe he's

1900

01:04:41,670 --> 01:04:40,480

asking can they research can they

1901

01:04:43,589 --> 01:04:41,680

contribute to research

1902

01:04:45,430 --> 01:04:43,599

i think this person wants to know can i

1903

01:04:47,029 --> 01:04:45,440

learn enough that i can

1904

01:04:49,670 --> 01:04:47,039

let's say understand one of your papers

1905

01:04:51,589 --> 01:04:49,680

if i'm starting at 40

1906

01:04:53,430 --> 01:04:51,599

i'm sure you could if you if you're

1907

01:04:54,710 --> 01:04:53,440

willing to spend enough time on it so

1908

01:04:57,109 --> 01:04:54,720

you have to remember that when people in

1909

01:04:58,630 --> 01:04:57,119

their 20s learning mathematics

1910

01:05:01,589 --> 01:04:58,640

as grad students whatever they're

1911

01:05:04,150 --> 01:05:01,599

spending you know 8 or 12 hours a day

1912

01:05:05,750 --> 01:05:04,160

every day for years learning it and if

1913

01:05:07,990 --> 01:05:05,760

you're prepared to put that amount of

1914

01:05:10,870 --> 01:05:08,000

time into it in your 40s

1915

01:05:12,230 --> 01:05:10,880

my guess would be you probably could the

1916

01:05:13,990 --> 01:05:12,240

problem is you know by the time people

1917

01:05:15,349 --> 01:05:14,000

are in their 40s they tend to have jobs

1918

01:05:17,270 --> 01:05:15,359

and kids and all sorts of other

1919

01:05:19,510 --> 01:05:17,280

distractions so

1920

01:05:21,990 --> 01:05:19,520

it's very much harder to put in the

1921

01:05:24,069 --> 01:05:22,000

amount of time necessary

1922

01:05:26,230 --> 01:05:24,079

boris costello wants to know your take

1923

01:05:28,710 --> 01:05:26,240

on the unreasonable effectiveness

1924

01:05:29,270 --> 01:05:28,720

of mathematics in the natural sciences

1925

01:05:32,470 --> 01:05:29,280

this has

1926

01:05:33,270 --> 01:05:32,480

really baffled me i mean that what was

1927

01:05:35,829 --> 01:05:33,280

my take on it

1928

01:05:36,549 --> 01:05:35,839

well that just sums it i mean so the

1929

01:05:38,230 --> 01:05:36,559

problem is there's

1930

01:05:39,990 --> 01:05:38,240

there seems to be no reason at all why

1931

01:05:41,190 --> 01:05:40,000

the universe should make any sense i

1932

01:05:43,029 --> 01:05:41,200

mean

1933

01:05:44,549 --> 01:05:43,039

you you imagine what people thought

1934

01:05:46,230 --> 01:05:44,559

about the way the universe works

1935

01:05:48,069 --> 01:05:46,240

you know two or three thousand years ago

1936

01:05:49,990 --> 01:05:48,079

you know things just happened for no

1937

01:05:50,710 --> 01:05:50,000

reason trees just grew because that's

1938

01:05:53,109 --> 01:05:50,720

what trees

1939

01:05:54,470 --> 01:05:53,119

did or maybe there was some god making

1940

01:05:56,309 --> 01:05:54,480

them grow or something and

1941

01:05:57,829 --> 01:05:56,319

we've discovered since then that nearly

1942

01:06:01,109 --> 01:05:57,839

everything seems to be

1943

01:06:04,470 --> 01:06:01,119

ultimately controlled by mathematics

1944

01:06:05,829 --> 01:06:04,480

and i've no idea why or no idea why this

1945

01:06:08,630 --> 01:06:05,839

should be true

1946

01:06:09,750 --> 01:06:08,640

um you know it's possible you could have

1947

01:06:11,910 --> 01:06:09,760

a universe that

1948

01:06:13,990 --> 01:06:11,920

that just sort of was like a universe

1949

01:06:16,150 --> 01:06:14,000

that sprang from the mind of a fantasy

1950

01:06:18,470 --> 01:06:16,160

author where things just worked by magic

1951

01:06:20,230 --> 01:06:18,480

for no particular reason but

1952

01:06:21,910 --> 01:06:20,240

we seem to be in one where it runs on

1953

01:06:24,069 --> 01:06:21,920

mathematics

1954

01:06:26,230 --> 01:06:24,079

rajesh v wants to know are you puzzled

1955

01:06:26,950 --> 01:06:26,240

by most people's inability to understand

1956

01:06:29,910 --> 01:06:26,960

math

1957

01:06:31,750 --> 01:06:29,920

or do you see a reason behind it i'm not

1958

01:06:33,670 --> 01:06:31,760

puzzled by most people's inability to

1959

01:06:35,510 --> 01:06:33,680

understand math what really puzzles me

1960

01:06:36,789 --> 01:06:35,520

is the fact that anyone can understand

1961

01:06:39,349 --> 01:06:36,799

math at all

1962

01:06:41,670 --> 01:06:39,359

i mean from a point of view if you're an

1963

01:06:44,630 --> 01:06:41,680

evolutionary psychologist

1964

01:06:46,230 --> 01:06:44,640

you can pretty much prove that no human

1965

01:06:47,990 --> 01:06:46,240

could possibly do mathematics because

1966

01:06:48,549 --> 01:06:48,000

you know think about where we evolved we

1967

01:06:50,470 --> 01:06:48,559

were

1968

01:06:51,670 --> 01:06:50,480

running around on the probably the

1969

01:06:53,349 --> 01:06:51,680

african plains being

1970

01:06:55,029 --> 01:06:53,359

chased by leopards or tigers or

1971

01:06:57,430 --> 01:06:55,039

something and if you get someone who

1972

01:06:58,630 --> 01:06:57,440

you know stops to wander about large

1973

01:07:00,069 --> 01:06:58,640

cardinals well

1974

01:07:01,670 --> 01:07:00,079

you know 10 minutes later they're going

1975

01:07:03,829 --> 01:07:01,680

to be passing through the digestive

1976

01:07:05,990 --> 01:07:03,839

system of some large carnivore

1977

01:07:08,390 --> 01:07:06,000

i mean the the mathematics gene should

1978

01:07:12,069 --> 01:07:08,400

have been wiped out by

1979

01:07:15,510 --> 01:07:12,079

um a high evolutionary pressure

1980

01:07:17,510 --> 01:07:15,520

so you know what why why do humans get

1981

01:07:19,990 --> 01:07:17,520

get interested in mathematics it's

1982

01:07:21,430 --> 01:07:20,000

this is what's difficult to explain

1983

01:07:22,710 --> 01:07:21,440

what's the longest time you've thought

1984

01:07:26,829 --> 01:07:22,720

about a problem before finding a

1985

01:07:34,549 --> 01:07:29,430

uh

1986

01:07:37,589 --> 01:07:36,630

i think let me see moonshine conjectures

1987

01:07:40,549 --> 01:07:37,599

were probably about

1988

01:07:42,390 --> 01:07:40,559

10 years um i might be able to give you

1989

01:07:44,150 --> 01:07:42,400

about 40 years and i don't know whether

1990

01:07:45,750 --> 01:07:44,160

i've actually solved the problem yet so

1991

01:07:47,029 --> 01:07:45,760

somewhere between 10 and 40 years

1992

01:07:48,710 --> 01:07:47,039

depending on whether the

1993

01:07:50,549 --> 01:07:48,720

problem i'm currently working on works

1994

01:07:52,789 --> 01:07:50,559

out or not is the problem you're

1995

01:07:54,309 --> 01:07:52,799

currently working on a monumentous one

1996

01:07:58,870 --> 01:07:54,319

is it one that people would recognize if

1997

01:08:02,069 --> 01:08:00,309

if i know that you stated my name

1998

01:08:03,829 --> 01:08:02,079

everyone would think i'd gone completely

1999

01:08:07,750 --> 01:08:03,839

mad so i'm not going to say anything

2000

01:08:11,349 --> 01:08:07,760

more about it it's about god isn't it

2001

01:08:13,190 --> 01:08:11,359

i said mad i didn't say crazy

2002

01:08:15,990 --> 01:08:13,200

what do you think of ramanajan a

2003

01:08:18,870 --> 01:08:16,000

self-taught math genius

2004

01:08:20,870 --> 01:08:18,880

this is just i'm just overwhelmed by it

2005

01:08:22,070 --> 01:08:20,880

because he he did something that

2006

01:08:23,829 --> 01:08:22,080

you know i thought would have been

2007

01:08:25,030 --> 01:08:23,839

almost impossible that's it that he

2008

01:08:27,110 --> 01:08:25,040

managed

2009

01:08:28,390 --> 01:08:27,120

by his own unaided efforts to turn

2010

01:08:30,630 --> 01:08:28,400

himself into one of the

2011

01:08:32,470 --> 01:08:30,640

you know greatest mathematicians i mean

2012

01:08:34,470 --> 01:08:32,480

you you look at what he was

2013

01:08:36,229 --> 01:08:34,480

growing up in he was he was growing up

2014

01:08:39,669 --> 01:08:36,239

in extreme poverty

2015

01:08:40,390 --> 01:08:39,679

and i mean even surviving in those

2016

01:08:42,550 --> 01:08:40,400

conditions

2017

01:08:43,510 --> 01:08:42,560

would have been as much as most people

2018

01:08:46,630 --> 01:08:43,520

could do and to

2019

01:08:50,149 --> 01:08:46,640

to do this phenomenal mathematics i just

2020

01:08:53,669 --> 01:08:50,159

cannot imagine how he did it um

2021

01:08:55,030 --> 01:08:53,679

i mean you know i mean ramanujan himself

2022

01:08:56,709 --> 01:08:55,040

said that you know how did he get his

2023

01:08:58,630 --> 01:08:56,719

mathematical formulas and he said he got

2024

01:08:59,749 --> 01:08:58,640

them in dreams from some goddess or

2025

01:09:01,749 --> 01:08:59,759

something and

2026

01:09:03,030 --> 01:09:01,759

i i can't actually think of it a better

2027

01:09:05,749 --> 01:09:03,040

explanation i mean

2028

01:09:07,510 --> 01:09:05,759

it's it's it's almost miraculous that he

2029

01:09:09,829 --> 01:09:07,520

managed to do this

2030

01:09:10,870 --> 01:09:09,839

right some of the formulas are so arcane

2031

01:09:12,709 --> 01:09:10,880

and so esoteric

2032

01:09:14,870 --> 01:09:12,719

that you wonder how can you come up with

2033

01:09:15,430 --> 01:09:14,880

it without deriving them and he would

2034

01:09:18,630 --> 01:09:15,440

just

2035

01:09:20,709 --> 01:09:18,640

they would turn out to be true well

2036

01:09:25,269 --> 01:09:20,719

i i don't know i i i think i think he

2037

01:09:28,550 --> 01:09:28,149

um i mean you know some mathematicians

2038

01:09:30,630 --> 01:09:28,560

have this

2039

01:09:32,309 --> 01:09:30,640

a bit of a desire to keep their methods

2040

01:09:34,149 --> 01:09:32,319

to themselves a bit and

2041

01:09:35,510 --> 01:09:34,159

maybe romantic was doing that to some

2042

01:09:37,910 --> 01:09:35,520

extent

2043

01:09:39,829 --> 01:09:37,920

um but i i really don't know i mean i've

2044

01:09:42,950 --> 01:09:39,839

looked at his

2045

01:09:44,870 --> 01:09:42,960

some of his papers and books and i just

2046

01:09:46,149 --> 01:09:44,880

i just cannot imagine how he thought of

2047

01:09:48,309 --> 01:09:46,159

them i mean

2048

01:09:50,229 --> 01:09:48,319

some of his formulas you can prove by

2049

01:09:52,950 --> 01:09:50,239

using techniques that ramanujan didn't

2050

01:09:54,950 --> 01:09:52,960

know about i mean it's kind of

2051
01:09:57,189 --> 01:09:54,960
notorious that manager never knew

2052
01:10:00,149 --> 01:09:57,199
complex analysis

2053
01:10:01,430 --> 01:10:00,159
which is a but he know which is a very

2054
01:10:04,070 --> 01:10:01,440
powerful method for

2055
01:10:05,750 --> 01:10:04,080
evaluating integrals but somehow he he

2056
01:10:07,669 --> 01:10:05,760
never seemed to feel the lack of it he

2057
01:10:10,310 --> 01:10:07,679
was able to do by

2058
01:10:12,470 --> 01:10:10,320
real variable methods what most of us

2059
01:10:15,590 --> 01:10:12,480
need complex variable methods to do

2060
01:10:17,270 --> 01:10:15,600
so somehow he just got

2061
01:10:19,430 --> 01:10:17,280
really really really good at real

2062
01:10:23,669 --> 01:10:19,440
variable methods in a way that almost

2063
01:10:26,470 --> 01:10:23,679

nobody since has managed to equal

2064

01:10:28,149 --> 01:10:26,480

bob bobady says thanks for the q a i'm

2065

01:10:30,310 --> 01:10:28,159

just wondering if you plan on continuing

2066

01:10:33,189 --> 01:10:30,320

your number theory series

2067

01:10:34,149 --> 01:10:33,199

yeah um the if you're talking about my

2068

01:10:36,070 --> 01:10:34,159

youtube channel

2069

01:10:37,669 --> 01:10:36,080

um well i i'm not really planning to but

2070

01:10:40,870 --> 01:10:37,679

i'm not planning not to it's

2071

01:10:42,630 --> 01:10:40,880

it's just sort of topics just

2072

01:10:44,070 --> 01:10:42,640

turn up at random depending on what i

2073

01:10:46,310 --> 01:10:44,080

feel like and what people

2074

01:10:47,750 --> 01:10:46,320

vote for and so on so probably if i if i

2075

01:10:49,430 --> 01:10:47,760

keep going number theory will probably

2076

01:10:51,270 --> 01:10:49,440

continue

2077

01:10:53,270 --> 01:10:51,280

i requested to you over email for you to

2078

01:10:56,550 --> 01:10:53,280

start a series on quantum field theory

2079

01:11:00,070 --> 01:10:56,560

what are the chances of that uh

2080

01:11:01,910 --> 01:11:00,080

not all that high because i i had a sort

2081

01:11:04,180 --> 01:11:01,920

of bad experience with it

2082

01:11:05,510 --> 01:11:04,190

like like i tried to understand it and

2083

01:11:07,510 --> 01:11:05,520

[Music]

2084

01:11:09,510 --> 01:11:07,520

you know invested a few years and felt

2085

01:11:13,110 --> 01:11:09,520

i'd really

2086

01:11:15,590 --> 01:11:13,120

it's like really hitting a concrete wall

2087

01:11:16,229 --> 01:11:15,600

when you read quantum field theory books

2088

01:11:18,310 --> 01:11:16,239

virtually

2089

01:11:19,430 --> 01:11:18,320

every one of them tackle the problem

2090

01:11:22,790 --> 01:11:19,440

differently

2091

01:11:23,350 --> 01:11:22,800

unlike mechanics or quantum mechanics

2092

01:11:25,270 --> 01:11:23,360

even

2093

01:11:27,189 --> 01:11:25,280

i would be so curious to see how you

2094

01:11:29,669 --> 01:11:27,199

tackled it

2095

01:11:30,390 --> 01:11:29,679

well that yeah so so when you say

2096

01:11:32,390 --> 01:11:30,400

different or

2097

01:11:33,350 --> 01:11:32,400

differently i think you you presumably

2098

01:11:34,630 --> 01:11:33,360

mean there are lots of different

2099

01:11:36,790 --> 01:11:34,640

approaches like you can do it by

2100

01:11:37,830 --> 01:11:36,800

operator algebras or by perturbation

2101

01:11:39,189 --> 01:11:37,840

theory or by

2102

01:11:41,110 --> 01:11:39,199

trying to make sense of infinite

2103

01:11:43,669 --> 01:11:41,120

dimensional integrals or by

2104

01:11:45,430 --> 01:11:43,679

doing topological quantum field theories

2105

01:11:46,790 --> 01:11:45,440

or whatever so so there are

2106

01:11:48,550 --> 01:11:46,800

all these different approaches and what

2107

01:11:50,229 --> 01:11:48,560

they all have in common is that none of

2108

01:11:53,110 --> 01:11:50,239

them really work

2109

01:11:54,310 --> 01:11:53,120

um so i was looking at all of them and

2110

01:11:56,470 --> 01:11:54,320

couldn't really make pretty much

2111

01:11:59,590 --> 01:11:56,480

progress on any of them

2112

01:12:00,149 --> 01:11:59,600

so i mean the the the one that people

2113

01:12:01,750 --> 01:12:00,159

have

2114

01:12:03,590 --> 01:12:01,760

that's been most successful is the

2115

01:12:06,310 --> 01:12:03,600

perturbation theory approach i mean this

2116

01:12:09,110 --> 01:12:06,320

is sort of what physicists actually use

2117

01:12:09,669 --> 01:12:09,120

to calculate numbers that they check in

2118

01:12:16,310 --> 01:12:09,679

um

2119

01:12:19,590 --> 01:12:16,320

you know perturbation theory produces

2120

01:12:21,350 --> 01:12:19,600

these divergent infinite series

2121

01:12:23,110 --> 01:12:21,360

and to make sense of them you cheat you

2122

01:12:24,950 --> 01:12:23,120

just take the first few terms which

2123

01:12:27,990 --> 01:12:24,960

makes no mathematical sense

2124

01:12:30,149 --> 01:12:28,000

and i was never able to

2125

01:12:31,830 --> 01:12:30,159

figure this out so you see an

2126
01:12:34,830 --> 01:12:31,840
arbitrariness as to when they choose to

2127
01:12:34,840 --> 01:12:38,790
well

2128
01:12:42,310 --> 01:12:40,470
maybe physicists who know more about

2129
01:12:43,990 --> 01:12:42,320
this would say it isn't arbitrary but as

2130
01:12:45,830 --> 01:12:44,000
far as i can figure out

2131
01:12:47,990 --> 01:12:45,840
that there didn't seem to be any very

2132
01:12:49,669 --> 01:12:48,000
good reason for stopping at some point

2133
01:12:52,310 --> 01:12:49,679
rather than another i mean

2134
01:12:54,229 --> 01:12:52,320
i guess you can stop when the terms

2135
01:12:58,270 --> 01:12:54,239
start getting bigger again but that's

2136
01:13:01,750 --> 01:13:00,790
ja524309 that's the username says i'm

2137
01:13:03,430 --> 01:13:01,760
curious

2138
01:13:05,189 --> 01:13:03,440

why you think memorizing proofs is

2139

01:13:06,630 --> 01:13:05,199

useless or less useful than doing

2140

01:13:09,110 --> 01:13:06,640

calculations

2141

01:13:10,550 --> 01:13:09,120

could you elaborate i should say i agree

2142

01:13:13,750 --> 01:13:10,560

with some of your other remarks

2143

01:13:15,910 --> 01:13:13,760

eg they're not being the best proof

2144

01:13:17,270 --> 01:13:15,920

of any particular theorem that was when

2145

01:13:20,149 --> 01:13:17,280

you were asked about

2146

01:13:21,189 --> 01:13:20,159

the book i was watching a talk by barry

2147

01:13:23,270 --> 01:13:21,199

mazur

2148

01:13:24,550 --> 01:13:23,280

the other day and he spoke also how

2149

01:13:26,310 --> 01:13:24,560

different proofs can sort

2150

01:13:28,229 --> 01:13:26,320

of allude to different possible

2151

01:13:29,750 --> 01:13:28,239

generalizations of the same problem

2152

01:13:32,149 --> 01:13:29,760

which may or may not necessarily

2153

01:13:37,350 --> 01:13:32,159

themselves be able which they may not

2154

01:13:40,790 --> 01:13:39,590

sorry that was yeah let me just read the

2155

01:13:42,550 --> 01:13:40,800

first part because i believe the

2156

01:13:43,430 --> 01:13:42,560

question is got confused by having two

2157

01:13:45,990 --> 01:13:43,440

questions right

2158

01:13:46,709 --> 01:13:46,000

oh i'm confused i'm confused reading it

2159

01:13:48,149 --> 01:13:46,719

okay

2160

01:13:49,910 --> 01:13:48,159

i'm curious why you think memorizing

2161

01:13:52,229 --> 01:13:49,920

proofs is less useful than doing okay

2162

01:13:53,669 --> 01:13:52,239

let's do that let's do that part first

2163

01:13:55,270 --> 01:13:53,679

um i think this is one of the things

2164

01:13:56,070 --> 01:13:55,280

that probably varies from person to

2165

01:13:58,870 --> 01:13:56,080

person so

2166

01:14:00,709 --> 01:13:58,880

so people have very different styles for

2167

01:14:02,470 --> 01:14:00,719

learning things and maybe for some

2168

01:14:04,550 --> 01:14:02,480

people memorizing proofs

2169

01:14:05,990 --> 01:14:04,560

is a useful thing i'm just saying for me

2170

01:14:08,390 --> 01:14:06,000

personally

2171

01:14:10,709 --> 01:14:08,400

i i never found memorizing proofs to be

2172

01:14:12,630 --> 01:14:10,719

very useful that's mainly because my

2173

01:14:13,990 --> 01:14:12,640

memory isn't as good as some people's i

2174

01:14:15,750 --> 01:14:14,000

mean i've i've

2175

01:14:17,110 --> 01:14:15,760

noticed that some people have incredible

2176

01:14:18,870 --> 01:14:17,120

memories i i mean

2177

01:14:20,709 --> 01:14:18,880

you know that they can sort of read a

2178

01:14:21,270 --> 01:14:20,719

book and basically recite it back word

2179

01:14:23,669 --> 01:14:21,280

for word

2180

01:14:24,550 --> 01:14:23,679

so so von neumann for example could do

2181

01:14:26,630 --> 01:14:24,560

that and

2182

01:14:27,990 --> 01:14:26,640

maybe for people like that that they can

2183

01:14:31,910 --> 01:14:28,000

memorize proofs but

2184

01:14:33,590 --> 01:14:31,920

for for me at least the i mean i i could

2185

01:14:35,590 --> 01:14:33,600

memorize a proof of i put a lot of

2186

01:14:38,550 --> 01:14:35,600

effort into it but it would be

2187

01:14:40,630 --> 01:14:38,560

you know i mean it's it's there's what

2188

01:14:42,470 --> 01:14:40,640

economists call an opportunity cost

2189

01:14:45,270 --> 01:14:42,480

my time is actually more productively

2190

01:14:47,430 --> 01:14:45,280

spent doing something else because

2191

01:14:48,550 --> 01:14:47,440

i i seem to learn i seem to understand

2192

01:14:51,510 --> 01:14:48,560

things better by actually doing

2193

01:14:55,110 --> 01:14:51,520

calculations with examples so

2194

01:14:56,709 --> 01:14:55,120

um so so i i guess my answer only

2195

01:14:58,790 --> 01:14:56,719

applies to me and doesn't necessarily

2196

01:15:01,669 --> 01:14:58,800

apply to other people

2197

01:15:02,790 --> 01:15:01,679

you mentioned learning styles yeah okay

2198

01:15:04,310 --> 01:15:02,800

so what are some of the different

2199

01:15:05,669 --> 01:15:04,320

learning styles and how does one figure

2200

01:15:08,870 --> 01:15:05,679

out their own

2201

01:15:12,070 --> 01:15:08,880

the one that fits for them well for me

2202

01:15:14,070 --> 01:15:12,080

learning is very very much i have to

2203

01:15:15,830 --> 01:15:14,080

my learning style is i as i said i need

2204

01:15:17,669 --> 01:15:15,840

to do calculations and i need to

2205

01:15:19,270 --> 01:15:17,679

read things over and over again because

2206

01:15:21,189 --> 01:15:19,280

i'm rather bad at

2207

01:15:23,030 --> 01:15:21,199

learning things other people's learning

2208

01:15:26,229 --> 01:15:23,040

styles i

2209

01:15:27,830 --> 01:15:26,239

i don't actually know much about because

2210

01:15:29,430 --> 01:15:27,840

all i can notice is that they're

2211

01:15:31,669 --> 01:15:29,440

obviously different from mine in some

2212

01:15:33,669 --> 01:15:31,679

ways

2213

01:15:35,350 --> 01:15:33,679

a really obvious one is i'm terrible at

2214

01:15:35,910 --> 01:15:35,360

learning languages whereas other people

2215

01:15:37,669 --> 01:15:35,920

can

2216

01:15:40,790 --> 01:15:37,679

learn languages really easily so they

2217

01:15:42,550 --> 01:15:40,800

must be doing something different

2218

01:15:44,950 --> 01:15:42,560

do you have a philosophy of mathematics

2219

01:15:46,550 --> 01:15:44,960

and if so what is it

2220

01:15:48,070 --> 01:15:46,560

philosophy of mathematics well this is

2221

01:15:51,430 --> 01:15:48,080

this is like the question about

2222

01:15:54,470 --> 01:15:51,440

what the right foundation should be and

2223

01:15:55,910 --> 01:15:54,480

as i said my that that there are several

2224

01:15:59,189 --> 01:15:55,920

underlying philosophies

2225

01:16:01,030 --> 01:15:59,199

so there's finitism where you think

2226
01:16:02,870 --> 01:16:01,040
everything should be computation and

2227
01:16:04,390 --> 01:16:02,880
platonism where you think everything

2228
01:16:04,950 --> 01:16:04,400
exists in some mystical realm and

2229
01:16:06,709 --> 01:16:04,960
there's

2230
01:16:08,070 --> 01:16:06,719
formalism where it's just a game you

2231
01:16:11,669 --> 01:16:08,080
play

2232
01:16:14,790 --> 01:16:11,679
with with with rules and

2233
01:16:16,709 --> 01:16:14,800
i'd say i i sort of

2234
01:16:18,709 --> 01:16:16,719
kind of oscillate between them or maybe

2235
01:16:20,950 --> 01:16:18,719
amalgamate them all i mean that

2236
01:16:21,830 --> 01:16:20,960
they all have some good points and some

2237
01:16:24,070 --> 01:16:21,840
bad points

2238
01:16:27,590 --> 01:16:24,080

so i don't really have a single

2239

01:16:31,669 --> 01:16:30,149

um kind of amalgamate all philosophies

2240

01:16:32,950 --> 01:16:31,679

and pick and choose whichever is most

2241

01:16:35,669 --> 01:16:32,960

convenient at the time

2242

01:16:37,270 --> 01:16:35,679

and it seems you know there seems to be

2243

01:16:39,110 --> 01:16:37,280

something a little bit off about this

2244

01:16:40,870 --> 01:16:39,120

it's like trying to belong to several

2245

01:16:43,350 --> 01:16:40,880

different religions all at once

2246

01:16:45,110 --> 01:16:43,360

but but somehow for mathematical

2247

01:16:45,750 --> 01:16:45,120

philosophies maybe you can get away with

2248

01:16:46,950 --> 01:16:45,760

it

2249

01:16:49,030 --> 01:16:46,960

what do you mean you pick and choose

2250

01:16:50,870 --> 01:16:49,040

which one's useful what would be an

2251

01:16:53,430 --> 01:16:50,880

example of one that's useful for you

2252

01:16:54,390 --> 01:16:53,440

um well i mean i think the different

2253

01:16:57,510 --> 01:16:54,400

philosophy

2254

01:16:58,790 --> 01:16:57,520

wouldn't really be useful for actually

2255

01:17:00,470 --> 01:16:58,800

doing math research

2256

01:17:02,149 --> 01:17:00,480

the different philosophies would be

2257

01:17:03,830 --> 01:17:02,159

useful for trying to understand what the

2258

01:17:05,590 --> 01:17:03,840

foundations of mathematics and the

2259

01:17:10,070 --> 01:17:05,600

universe are

2260

01:17:12,790 --> 01:17:10,080

um so if you if you think the universe

2261

01:17:14,790 --> 01:17:12,800

should be based on computation then

2262

01:17:16,709 --> 01:17:14,800

maybe you try working with a

2263

01:17:18,550 --> 01:17:16,719

finitistic computational model of

2264

01:17:21,030 --> 01:17:18,560

mathematics

2265

01:17:21,910 --> 01:17:21,040

um if you if you're trying to understand

2266

01:17:25,510 --> 01:17:21,920

some

2267

01:17:27,350 --> 01:17:25,520

deep complicated theorem then

2268

01:17:29,270 --> 01:17:27,360

it's it's very difficult to prove these

2269

01:17:31,430 --> 01:17:29,280

theorems in a finitistic model so you

2270

01:17:34,310 --> 01:17:31,440

may have to sort of switch to a

2271

01:17:35,110 --> 01:17:34,320

more platonic model where there is you

2272

01:17:37,030 --> 01:17:35,120

know you

2273

01:17:38,870 --> 01:17:37,040

you you assume the existence of very

2274

01:17:40,149 --> 01:17:38,880

strong constructions like the power set

2275

01:17:42,550 --> 01:17:40,159

of a set

2276

01:17:44,550 --> 01:17:42,560

i mean it's very difficult developing

2277

01:17:45,110 --> 01:17:44,560

things like general topology for example

2278

01:17:48,870 --> 01:17:45,120

in the

2279

01:17:50,870 --> 01:17:48,880

in a finitistic universe

2280

01:17:52,229 --> 01:17:50,880

how does one know by the way this

2281

01:17:53,590 --> 01:17:52,239

question is from bag bigger

2282

01:17:55,430 --> 01:17:53,600

how does one know when they're on the

2283

01:17:57,669 --> 01:17:55,440

right path in finding a solution

2284

01:17:59,110 --> 01:17:57,679

i've tried substantial unsolved problems

2285

01:18:00,550 --> 01:17:59,120

and i end up making progress

2286

01:18:03,750 --> 01:18:00,560

but then i feel like i'm chasing my own

2287

01:18:04,709 --> 01:18:03,760

tail this is one of the hardest problems

2288

01:18:07,030 --> 01:18:04,719

in research

2289

01:18:08,470 --> 01:18:07,040

and if you you know if you could solve

2290

01:18:10,229 --> 01:18:08,480

this problem

2291

01:18:12,229 --> 01:18:10,239

you you become the world's greatest

2292

01:18:14,310 --> 01:18:12,239

mathematician it's sort of like asking

2293

01:18:16,390 --> 01:18:14,320

how do you time the stock market

2294

01:18:18,550 --> 01:18:16,400

nobody knows how to do it and if you if

2295

01:18:21,270 --> 01:18:18,560

you could you'd be really rich

2296

01:18:22,550 --> 01:18:21,280

um so so that it's this question of

2297

01:18:26,149 --> 01:18:22,560

knowing

2298

01:18:29,110 --> 01:18:26,159

what the right solution to a problem is

2299

01:18:30,550 --> 01:18:29,120

the right way to solve a problem is and

2300

01:18:32,310 --> 01:18:30,560

you know i mean

2301

01:18:34,229 --> 01:18:32,320

this is in some sense the hardest part

2302

01:18:36,310 --> 01:18:34,239

of research trying to trying to figure

2303

01:18:37,750 --> 01:18:36,320

out whether you're on track or not

2304

01:18:40,709 --> 01:18:37,760

um i heard a story about that there was

2305

01:18:43,030 --> 01:18:40,719

this mathematician called nagata who was

2306

01:18:45,189 --> 01:18:43,040

you know half his work was proving these

2307

01:18:46,950 --> 01:18:45,199

amazing theorems and half his work was

2308

01:18:48,229 --> 01:18:46,960

proven these stunning counter examples

2309

01:18:49,830 --> 01:18:48,239

to theorems and

2310

01:18:51,590 --> 01:18:49,840

the story i heard was that you know

2311

01:18:52,310 --> 01:18:51,600

every morning he would try and prove a

2312

01:18:53,750 --> 01:18:52,320

theorem

2313

01:18:56,149 --> 01:18:53,760

and every afternoon he would try and

2314

01:18:57,830 --> 01:18:56,159

find a counter example so so one or the

2315

01:19:00,709 --> 01:18:57,840

other would work out so so

2316

01:19:02,149 --> 01:19:00,719

so he had both both bases covered in

2317

01:19:04,070 --> 01:19:02,159

some sense he he

2318

01:19:05,590 --> 01:19:04,080

he he didn't need to know when he was on

2319

01:19:08,149 --> 01:19:05,600

the right track because he was trying

2320

01:19:10,149 --> 01:19:08,159

all possible tracks simultaneously

2321

01:19:12,630 --> 01:19:10,159

and and just found out which one worked

2322

01:19:14,630 --> 01:19:12,640

by trying everything

2323

01:19:16,149 --> 01:19:14,640

tahum asks can you explain langlin's

2324

01:19:18,070 --> 01:19:16,159

program and does it have any connection

2325

01:19:22,070 --> 01:19:18,080

to physics

2326

01:19:23,990 --> 01:19:22,080

no yes um langland's program

2327

01:19:25,590 --> 01:19:24,000

if you had to say it in one sentence it

2328

01:19:28,630 --> 01:19:25,600

would say that

2329

01:19:30,390 --> 01:19:28,640

um automorphic forms on groups have

2330

01:19:32,950 --> 01:19:30,400

something to do with

2331

01:19:34,630 --> 01:19:32,960

representations of galway groups which

2332

01:19:38,229 --> 01:19:34,640

sounds like this

2333

01:19:40,950 --> 01:19:38,239

obscure technical stuff

2334

01:19:42,709 --> 01:19:40,960

but um rather amazingly an awful lot of

2335

01:19:45,270 --> 01:19:42,719

problems in mathematics

2336

01:19:47,430 --> 01:19:45,280

turn out if you go very deep into them

2337

01:19:50,310 --> 01:19:47,440

to to be related to the langlens

2338

01:19:51,990 --> 01:19:50,320

program for example um the classic

2339

01:19:54,149 --> 01:19:52,000

example of this is wireless as proof of

2340

01:19:56,070 --> 01:19:54,159

firma's last theorem was was essentially

2341

01:19:57,590 --> 01:19:56,080

using this idea

2342

01:20:00,229 --> 01:19:57,600

um does it have anything to do with

2343

01:20:01,590 --> 01:20:00,239

physics well

2344

01:20:03,910 --> 01:20:01,600

some of the more recent work on

2345

01:20:06,390 --> 01:20:03,920

geometric langlands is using ideas from

2346

01:20:08,229 --> 01:20:06,400

quantum field theory so

2347

01:20:09,430 --> 01:20:08,239

i can give you a definite maybe on that

2348

01:20:12,390 --> 01:20:09,440

one

2349

01:20:14,070 --> 01:20:12,400

um there are certainly some ideas that

2350

01:20:15,590 --> 01:20:14,080

turn up in both langman's program and

2351
01:20:17,510 --> 01:20:15,600
physics whether or not there's any more

2352
01:20:20,070 --> 01:20:17,520
direct connection

2353
01:20:21,750 --> 01:20:20,080
i don't know but it wouldn't surprise me

2354
01:20:22,950 --> 01:20:21,760
langland's program seems to

2355
01:20:24,629 --> 01:20:22,960
it seems to be one of these things that

2356
01:20:27,110 --> 01:20:24,639
turns up almost everywhere if you go

2357
01:20:28,310 --> 01:20:27,120
really deeply into something

2358
01:20:31,030 --> 01:20:28,320
you mentioned that you're extremely

2359
01:20:33,669 --> 01:20:31,040
interested in learning more about it

2360
01:20:35,350 --> 01:20:33,679
i've been so for decades and there's

2361
01:20:38,629 --> 01:20:35,360
there's just so much to learn

2362
01:20:40,629 --> 01:20:38,639
i mean um

2363
01:20:42,629 --> 01:20:40,639

i mean that langland's program seems to

2364

01:20:44,950 --> 01:20:42,639

be the ultimate black hole for what you

2365

01:20:47,350 --> 01:20:44,960

need to learn in order to understand it

2366

01:20:49,669 --> 01:20:47,360

like there are there are several very

2367

01:20:51,189 --> 01:20:49,679

deep subjects like representation theory

2368

01:20:53,750 --> 01:20:51,199

and algebraic geometry which are

2369

01:20:55,430 --> 01:20:53,760

themselves notorious for how

2370

01:20:56,870 --> 01:20:55,440

how much you have to learn to get into

2371

01:20:59,510 --> 01:20:56,880

them and langlen's program

2372

01:21:00,950 --> 01:20:59,520

sort of sub sums all of these you need

2373

01:21:02,629 --> 01:21:00,960

to know algebraic geometry and

2374

01:21:04,629 --> 01:21:02,639

representation theory

2375

01:21:05,990 --> 01:21:04,639

and a lot of hard analysis so it's more

2376

01:21:07,750 --> 01:21:06,000

or less

2377

01:21:10,470 --> 01:21:07,760

it's almost like it's every hard area of

2378

01:21:12,310 --> 01:21:10,480

mathematics all combined into one

2379

01:21:13,590 --> 01:21:12,320

well you do have a course on

2380

01:21:16,950 --> 01:21:13,600

representation theory

2381

01:21:17,590 --> 01:21:16,960

and on algebraic geometry so you should

2382

01:21:19,669 --> 01:21:17,600

have some

2383

01:21:21,750 --> 01:21:19,679

advantage there no these are just

2384

01:21:22,390 --> 01:21:21,760

scratching the surface of what you need

2385

01:21:24,629 --> 01:21:22,400

to know

2386

01:21:25,990 --> 01:21:24,639

the representation theory i've put on is

2387

01:21:28,229 --> 01:21:26,000

just finite

2388

01:21:30,390 --> 01:21:28,239

groups in characteristic zero which is

2389

01:21:32,470 --> 01:21:30,400

the

2390

01:21:34,310 --> 01:21:32,480

easiest example it's not quite trivial

2391

01:21:37,189 --> 01:21:34,320

but it's it's the really easy part of

2392

01:21:40,709 --> 01:21:37,199

representation theory langland's program

2393

01:21:43,910 --> 01:21:42,470

infinite groups the representations

2394

01:21:45,830 --> 01:21:43,920

become infinite dimensional

2395

01:21:47,910 --> 01:21:45,840

everything becomes far far more

2396

01:21:51,110 --> 01:21:47,920

complicated

2397

01:21:52,790 --> 01:21:51,120

just us perths asks how can a person

2398

01:21:53,510 --> 01:21:52,800

who's self-studying deal with gaps in

2399

01:21:56,149 --> 01:21:53,520

knowledge

2400

01:21:57,270 --> 01:21:56,159

when i get stuck on a new concept i'm

2401

01:21:58,790 --> 01:21:57,280

often unsure

2402

01:22:00,870 --> 01:21:58,800

exactly what it is that's preventing me

2403

01:22:02,550 --> 01:22:00,880

from understanding it and i

2404

01:22:04,070 --> 01:22:02,560

in other words i don't know what i don't

2405

01:22:06,149 --> 01:22:04,080

know well one

2406

01:22:07,990 --> 01:22:06,159

one thing you can do these days is is

2407

01:22:09,669 --> 01:22:08,000

there are lots of math discussion groups

2408

01:22:09,990 --> 01:22:09,679

on things like reddit and you can just

2409

01:22:12,310 --> 01:22:10,000

try

2410

01:22:14,149 --> 01:22:12,320

asking i mean you may have to poke

2411

01:22:16,310 --> 01:22:14,159

around a bit to find the right sort of

2412

01:22:18,390 --> 01:22:16,320

math discussion group to answer whatever

2413

01:22:22,149 --> 01:22:18,400

level of question you're asking

2414

01:22:25,430 --> 01:22:22,159

um some groups i think there's a

2415

01:22:29,350 --> 01:22:25,440

there's if you search for math overflow

2416

01:22:31,189 --> 01:22:29,360

and math stack exchange these

2417

01:22:32,470 --> 01:22:31,199

uh where you can ask questions and

2418

01:22:34,790 --> 01:22:32,480

you'll quite often get

2419

01:22:35,910 --> 01:22:34,800

serious answers from from mathematicians

2420

01:22:38,790 --> 01:22:35,920

about them

2421

01:22:40,709 --> 01:22:38,800

okay for the people watching please ask

2422

01:22:42,470 --> 01:22:40,719

any further questions because i'm gonna

2423

01:22:43,990 --> 01:22:42,480

end this at some point soon but make

2424

01:22:45,910 --> 01:22:44,000

sure your question is asked in such a

2425

01:22:47,270 --> 01:22:45,920

way that if i read it verbatim it makes

2426

01:22:48,310 --> 01:22:47,280

sense because i don't like having to

2427

01:22:50,790 --> 01:22:48,320

parse them

2428

01:22:52,550 --> 01:22:50,800

in real time just one question at a time

2429

01:22:54,550 --> 01:22:52,560

because my short-term memory seems to

2430

01:22:56,870 --> 01:22:54,560

getting worse and worse yes just

2431

01:22:58,550 --> 01:22:56,880

keep it at the length of one sentence

2432

01:23:02,070 --> 01:22:58,560

one short one

2433

01:23:03,110 --> 01:23:02,080

14-word sentence okay what have you been

2434

01:23:11,350 --> 01:23:03,120

reading recently

2435

01:23:15,189 --> 01:23:13,030

my mind is for some reason completely

2436

01:23:19,189 --> 01:23:15,199

blanking out on this

2437

01:23:24,149 --> 01:23:22,149

um i mean i can give a boring answer of

2438

01:23:26,480 --> 01:23:24,159

all the books i was reading for my

2439

01:23:27,830 --> 01:23:26,490

youtube videos um

2440

01:23:29,750 --> 01:23:27,840

[Music]

2441

01:23:31,270 --> 01:23:29,760

and you tend to look at older books at

2442

01:23:32,550 --> 01:23:31,280

least you reference them plenty for

2443

01:23:33,590 --> 01:23:32,560

example you referenced a book that was

2444

01:23:35,430 --> 01:23:33,600

100 years old

2445

01:23:36,790 --> 01:23:35,440

where the calculation where the graphics

2446

01:23:40,149 --> 01:23:36,800

look like it's modern graphic

2447

01:23:43,270 --> 01:23:40,159

but it was oh yeah yeah

2448

01:23:45,270 --> 01:23:43,280

that yeah that's that's that that book

2449

01:23:46,870 --> 01:23:45,280

is absolutely fantastic because it's

2450

01:23:48,709 --> 01:23:46,880

it's got all

2451

01:23:50,950 --> 01:23:48,719

you know it's written in the days before

2452

01:23:52,870 --> 01:23:50,960

computers and the graphics there just

2453

01:23:55,590 --> 01:23:52,880

blow away most of the graphics people

2454

01:23:57,590 --> 01:23:55,600

produce by computer these days somehow

2455

01:23:59,590 --> 01:23:57,600

their pictures have a sort of soul in

2456

01:24:01,110 --> 01:23:59,600

them whereas if you if you just get a

2457

01:24:04,950 --> 01:24:01,120

computer to draw a graph of

2458

01:24:08,229 --> 01:24:04,960

function it's just you know the is

2459

01:24:09,270 --> 01:24:08,239

it's just not there yeah yeah the heart

2460

01:24:12,470 --> 01:24:09,280

isn't in it

2461

01:24:12,709 --> 01:24:12,480

exactly i mean that the you know known

2462

01:24:16,310 --> 01:24:12,719

as

2463

01:24:19,030 --> 01:24:16,320

and you're just not interested

2464

01:24:19,990 --> 01:24:19,040

and i can't imagine how they did it i

2465

01:24:23,030 --> 01:24:20,000

mean that they're just

2466

01:24:24,950 --> 01:24:23,040

pages and pages of numerical data they

2467

01:24:25,830 --> 01:24:24,960

must have all done by hand and that

2468

01:24:27,669 --> 01:24:25,840

there are

2469

01:24:30,790 --> 01:24:27,679

pages and pages of graphs that must have

2470

01:24:32,310 --> 01:24:30,800

been painstakingly drawn and calculated

2471

01:24:35,030 --> 01:24:32,320

i mean that the amount of effort they

2472

01:24:37,030 --> 01:24:35,040

put into that is just extraordinary

2473

01:24:38,629 --> 01:24:37,040

how are you finding youtube by the way i

2474

01:24:41,110 --> 01:24:38,639

imagine it's new for you

2475

01:24:42,149 --> 01:24:41,120

um it's it's interesting and very

2476

01:24:45,030 --> 01:24:42,159

stressful as

2477

01:24:47,189 --> 01:24:45,040

i said i get really really bugged out by

2478

01:24:50,550 --> 01:24:47,199

making mistakes on my videos

2479

01:24:52,950 --> 01:24:50,560

it's it's just it's just so embarrassing

2480

01:24:56,390 --> 01:24:52,960

having these

2481

01:24:57,990 --> 01:24:56,400

well um what i was thinking is um

2482

01:25:00,070 --> 01:24:58,000

what it reminds me of you you know you

2483

01:25:01,830 --> 01:25:00,080

get these books um written

2484

01:25:03,830 --> 01:25:01,840

you know that the million stupidest

2485

01:25:06,310 --> 01:25:03,840

things ever said by professor watts

2486

01:25:07,430 --> 01:25:06,320

by by president watts's name and things

2487

01:25:09,189 --> 01:25:07,440

like that

2488

01:25:11,270 --> 01:25:09,199

i suddenly have an awful lot more

2489

01:25:13,110 --> 01:25:11,280

sympathy for president watts's name who

2490

01:25:14,629 --> 01:25:13,120

who blurts out something stupid whenever

2491

01:25:16,790 --> 01:25:14,639

he opens his mouth because i've noticed

2492

01:25:20,229 --> 01:25:16,800

in my youtube videos i'm continually

2493

01:25:22,470 --> 01:25:20,239

making really really dumb mistakes

2494

01:25:23,669 --> 01:25:22,480

i mean it seems to be almost impossible

2495

01:25:25,910 --> 01:25:23,679

not to you

2496

01:25:27,270 --> 01:25:25,920

you can prepare and check everything and

2497

01:25:28,229 --> 01:25:27,280

it doesn't matter when you're actually

2498

01:25:31,750 --> 01:25:28,239

talking the stress

2499

01:25:32,950 --> 01:25:31,760

causes you to say really dumb things

2500

01:25:35,750 --> 01:25:32,960

you get stressed out when you're making

2501
01:25:37,830 --> 01:25:35,760
your youtube videos it's somehow very

2502
01:25:39,910 --> 01:25:37,840
yeah yeah it's it's very stressful and

2503
01:25:41,510 --> 01:25:39,920
when you're stressed your mind just

2504
01:25:44,310 --> 01:25:41,520
closes down and you

2505
01:25:46,470 --> 01:25:44,320
you make the dumbest mistakes and you

2506
01:25:47,990 --> 01:25:46,480
get to the end of the video and you

2507
01:25:50,470 --> 01:25:48,000
wonder how you could have said something

2508
01:25:51,910 --> 01:25:50,480
so stupid what is it about it that you

2509
01:25:52,950 --> 01:25:51,920
like so you just mentioned a negative

2510
01:25:55,350 --> 01:25:52,960
aspect

2511
01:25:56,709 --> 01:25:55,360
well it gives me something to do i mean

2512
01:25:58,149 --> 01:25:56,719
as i said research

2513
01:25:59,830 --> 01:25:58,159

consists most of the time of getting

2514

01:26:01,669 --> 01:25:59,840

nowhere and if you're making youtube

2515

01:26:02,709 --> 01:26:01,679

videos you're at least doing something

2516

01:26:04,390 --> 01:26:02,719

and

2517

01:26:06,470 --> 01:26:04,400

um i was rather surprised people

2518

01:26:09,189 --> 01:26:06,480

actually seem to like watching

2519

01:26:10,870 --> 01:26:09,199

math lectures on youtube i mean yeah i

2520

01:26:12,709 --> 01:26:10,880

mean i i started putting these videos

2521

01:26:14,470 --> 01:26:12,719

because they were my

2522

01:26:15,910 --> 01:26:14,480

you know lectures for courses i supposed

2523

01:26:18,950 --> 01:26:15,920

to be teaching and i had to

2524

01:26:21,189 --> 01:26:18,960

make some videos for them and

2525

01:26:22,550 --> 01:26:21,199

i i sort of didn't really occur to me

2526

01:26:25,030 --> 01:26:22,560

that people would actually watch them

2527

01:26:25,990 --> 01:26:25,040

for fun because i i can't stand watching

2528

01:26:28,149 --> 01:26:26,000

lectures

2529

01:26:29,669 --> 01:26:28,159

um so but other people obviously learn

2530

01:26:31,350 --> 01:26:29,679

differently

2531

01:26:33,590 --> 01:26:31,360

how much time do you spend thinking

2532

01:26:35,669 --> 01:26:33,600

about your own particular background on

2533

01:26:37,030 --> 01:26:35,679

knowledge and skills and relating it to

2534

01:26:39,510 --> 01:26:37,040

previous knowledge

2535

01:26:41,990 --> 01:26:39,520

versus spending time thinking without

2536

01:26:46,070 --> 01:26:42,000

relating

2537

01:26:48,830 --> 01:26:46,080

uh gosh that's a abstract question i'm

2538

01:26:51,830 --> 01:26:48,840

not quite sure

2539

01:26:53,990 --> 01:26:51,840

um i i would

2540

01:26:55,990 --> 01:26:54,000

say i'll try and answer it i would say

2541

01:26:57,669 --> 01:26:56,000

that nearly everything i do i'm trying

2542

01:27:00,790 --> 01:26:57,679

to relate it to other things

2543

01:27:03,270 --> 01:27:00,800

other things i know i mean a lot of

2544

01:27:04,070 --> 01:27:03,280

what research consists of is making

2545

01:27:06,229 --> 01:27:04,080

unexpected

2546

01:27:07,350 --> 01:27:06,239

connections between things so so if

2547

01:27:10,870 --> 01:27:07,360

you're

2548

01:27:11,910 --> 01:27:10,880

that has no connections to anything you

2549

01:27:13,750 --> 01:27:11,920

know in the past

2550

01:27:15,110 --> 01:27:13,760

it's going to be really really difficult

2551
01:27:17,510 --> 01:27:15,120
because it's going to take a lot of time

2552
01:27:19,030 --> 01:27:17,520
to build up

2553
01:27:21,590 --> 01:27:19,040
enough knowledge to start making

2554
01:27:23,990 --> 01:27:21,600
connections so so you really want to be

2555
01:27:25,430 --> 01:27:24,000
relating everything you do to

2556
01:27:28,229 --> 01:27:25,440
hopefully to something you've done

2557
01:27:32,310 --> 01:27:30,149
i mean you you're trying to build up a

2558
01:27:34,790 --> 01:27:32,320
big in connected web not have a lot of

2559
01:27:36,709 --> 01:27:34,800
series of discrete

2560
01:27:38,390 --> 01:27:36,719
domains of information that have nothing

2561
01:27:41,030 --> 01:27:38,400
to do with each other

2562
01:27:42,070 --> 01:27:41,040
neon dagger asks math people often talk

2563
01:27:44,470 --> 01:27:42,080

about being drawn

2564

01:27:45,669 --> 01:27:44,480

in by a wow subject that is hidden from

2565

01:27:47,830 --> 01:27:45,679

them earlier on

2566

01:27:50,790 --> 01:27:47,840

is it important to wow students to draw

2567

01:27:54,629 --> 01:27:52,870

um if you're trying to encourage people

2568

01:27:55,430 --> 01:27:54,639

to do mathematics this would be one way

2569

01:27:57,910 --> 01:27:55,440

of doing it

2570

01:27:59,030 --> 01:27:57,920

but it's again one of these things where

2571

01:28:01,030 --> 01:27:59,040

different people have different

2572

01:28:02,149 --> 01:28:01,040

approaches that some people are drawn in

2573

01:28:04,070 --> 01:28:02,159

by this

2574

01:28:05,750 --> 01:28:04,080

wow thing and others have drawn in

2575

01:28:09,030 --> 01:28:05,760

because they

2576

01:28:12,830 --> 01:28:09,040

the the they're just in they

2577

01:28:14,070 --> 01:28:12,840

they're just like working steadily for

2578

01:28:16,310 --> 01:28:14,080

um

2579

01:28:17,830 --> 01:28:16,320

your your hang on your your screen has

2580

01:28:19,910 --> 01:28:17,840

gone very weird

2581

01:28:22,149 --> 01:28:19,920

oh okay one second where we go there we

2582

01:28:24,629 --> 01:28:22,159

go there we go

2583

01:28:26,550 --> 01:28:24,639

do you remember what you were saying as

2584

01:28:29,189 --> 01:28:26,560

i said i'm under stress which makes my

2585

01:28:31,590 --> 01:28:29,199

short term memory even worse than usual

2586

01:28:32,870 --> 01:28:31,600

do you feel stressed being interviewed

2587

01:28:35,830 --> 01:28:32,880

right now

2588

01:28:36,870 --> 01:28:35,840

very much so i mean i i've noticed i've

2589

01:28:39,270 --> 01:28:36,880

noticed this that

2590

01:28:40,310 --> 01:28:39,280

i'm having great difficulty thinking

2591

01:28:42,310 --> 01:28:40,320

about

2592

01:28:43,990 --> 01:28:42,320

questions that people ask um i have the

2593

01:28:45,830 --> 01:28:44,000

same phenomenon in lectures people ask

2594

01:28:47,510 --> 01:28:45,840

me a question in a lecture and i've

2595

01:28:48,950 --> 01:28:47,520

no idea what the answer is and then i

2596

01:28:52,149 --> 01:28:48,960

get out of the lecture and it's

2597

01:28:53,910 --> 01:28:52,159

it's completely obvious so somehow

2598

01:28:55,350 --> 01:28:53,920

yeah yeah being interviewed or talking

2599

01:28:57,590 --> 01:28:55,360

whatever the

2600

01:28:58,470 --> 01:28:57,600

the high parts of my brain simply close

2601
01:29:04,709 --> 01:28:58,480
down

2602
01:29:04,719 --> 01:29:08,149
i think well

2603
01:29:11,910 --> 01:29:10,950
not not very um i mean there's seen here

2604
01:29:13,910 --> 01:29:11,920
one or two people

2605
01:29:15,590 --> 01:29:13,920
asking me for you know their

2606
01:29:16,950 --> 01:29:15,600
undergraduates doing projects where they

2607
01:29:19,030 --> 01:29:16,960
have to interview a professor or

2608
01:29:21,270 --> 01:29:19,040
something so

2609
01:29:22,629 --> 01:29:21,280
i've had maybe two or three um

2610
01:29:25,270 --> 01:29:22,639
interviews yours

2611
01:29:27,030 --> 01:29:25,280
your screen has gone weird again okay

2612
01:29:27,669 --> 01:29:27,040
okay let me just switch cameras then

2613
01:29:31,270 --> 01:29:27,679

completely

2614

01:29:32,950 --> 01:29:31,280

i have a feeling it's just overheating

2615

01:29:35,030 --> 01:29:32,960

yeah i was looking just so you know i

2616

01:29:36,709 --> 01:29:35,040

was looking for interviews of you

2617

01:29:42,310 --> 01:29:36,719

other people doing podcasts with you and

2618

01:29:48,149 --> 01:29:44,390

okay what's up with goldbach's

2619

01:29:52,149 --> 01:29:50,149

i don't really know why it's hard to

2620

01:29:54,790 --> 01:29:52,159

crack um

2621

01:29:56,229 --> 01:29:54,800

it's people have got very close i think

2622

01:30:00,470 --> 01:29:56,239

there was a

2623

01:30:02,229 --> 01:30:00,480

um i think

2624

01:30:03,910 --> 01:30:02,239

this isn't my area so i may have

2625

01:30:04,950 --> 01:30:03,920

misremembered i think there's a chinese

2626

01:30:07,030 --> 01:30:04,960

mathematician maybe

2627

01:30:08,950 --> 01:30:07,040

chen or something who who managed to get

2628

01:30:10,070 --> 01:30:08,960

very close so so goldback's conjecture

2629

01:30:13,430 --> 01:30:10,080

says that

2630

01:30:17,110 --> 01:30:13,440

um um every uh

2631

01:30:20,149 --> 01:30:17,120

which every even number is the sum of

2632

01:30:21,270 --> 01:30:20,159

two primes and you can get quite close

2633

01:30:22,709 --> 01:30:21,280

to that that

2634

01:30:24,470 --> 01:30:22,719

with a lot of work you can prove that

2635

01:30:27,350 --> 01:30:24,480

every even number is the sum of a prime

2636

01:30:29,189 --> 01:30:27,360

and a product of two primes

2637

01:30:31,110 --> 01:30:29,199

and for some reason there's some

2638

01:30:32,550 --> 01:30:31,120

horrible obstruction to going any

2639

01:30:33,990 --> 01:30:32,560

further than that

2640

01:30:36,629 --> 01:30:34,000

and i've never managed to understand

2641

01:30:37,350 --> 01:30:36,639

what the instruction is um i think terry

2642

01:30:39,350 --> 01:30:37,360

tau

2643

01:30:40,709 --> 01:30:39,360

who you mentioned i i once saw a

2644

01:30:41,990 --> 01:30:40,719

discussion by him of what this

2645

01:30:45,270 --> 01:30:42,000

obstruction is so

2646

01:30:46,470 --> 01:30:45,280

he might be the better person to ask um

2647

01:30:49,510 --> 01:30:46,480

and again

2648

01:30:51,510 --> 01:30:49,520

you can we we can prove that every odd

2649

01:30:53,350 --> 01:30:51,520

number is the sum of three primes

2650

01:30:55,750 --> 01:30:53,360

so we've got three primes instead of two

2651
01:30:57,510 --> 01:30:55,760
primes so we've got very close to it but

2652
01:30:59,990 --> 01:30:57,520
again there seems to be this weird

2653
01:31:03,270 --> 01:31:00,000
obstruction to pushing that last little

2654
01:31:06,709 --> 01:31:03,280
little step um

2655
01:31:08,390 --> 01:31:06,719
so as i said it's not my area so i don't

2656
01:31:11,669 --> 01:31:08,400
know exactly what this obstruction

2657
01:31:14,390 --> 01:31:11,679
is elham romanti

2658
01:31:16,390 --> 01:31:14,400
or rahami asks what advice do you have

2659
01:31:18,229 --> 01:31:16,400
for someone in their 20s trying to learn

2660
01:31:19,910 --> 01:31:18,239
math

2661
01:31:21,270 --> 01:31:19,920
um i know variations on this question

2662
01:31:23,510 --> 01:31:21,280
i've been asked before already

2663
01:31:25,510 --> 01:31:23,520

well go for it i mean i mean it it

2664

01:31:27,189 --> 01:31:25,520

depends very much on how much time you

2665

01:31:29,510 --> 01:31:27,199

can spare to put into it i mean people

2666

01:31:31,270 --> 01:31:29,520

in their 20s are quite often trying to

2667

01:31:34,070 --> 01:31:31,280

have their career starting up so may not

2668

01:31:37,590 --> 01:31:34,080

actually have a whole lot of spare time

2669

01:31:39,270 --> 01:31:37,600

um um

2670

01:31:40,870 --> 01:31:39,280

so i'm probably just repeating the

2671

01:31:42,310 --> 01:31:40,880

answer i gave earlier but

2672

01:31:45,350 --> 01:31:42,320

my advice would be to find something

2673

01:31:47,030 --> 01:31:45,360

you're really interested in and

2674

01:31:49,910 --> 01:31:47,040

my usual suggestion for that is

2675

01:31:52,470 --> 01:31:49,920

something like modular forms which is

2676

01:31:54,470 --> 01:31:52,480

the but that that's the area i found

2677

01:31:56,149 --> 01:31:54,480

particularly striking

2678

01:31:57,510 --> 01:31:56,159

i just wanted to conclude by saying

2679

01:31:58,790 --> 01:31:57,520

thank you i appreciate you being

2680

01:32:01,110 --> 01:31:58,800

generous with your time

2681

01:32:02,310 --> 01:32:01,120

i watch your videos i gain from them and

2682

01:32:04,070 --> 01:32:02,320

i'm pretty sure

2683

01:32:05,669 --> 01:32:04,080

plenty of the audience from this channel

2684

01:32:08,950 --> 01:32:05,679

will gain from it as well

2685

01:32:11,270 --> 01:32:08,960

yeah well i i i'm sort of

2686

01:32:14,149 --> 01:32:11,280

i i think having interviews like this is

2687

01:32:17,110 --> 01:32:14,159

really good practice for me since i'm

2688

01:32:19,110 --> 01:32:17,120

as you know as i show you observed i'm

2689

01:32:21,750 --> 01:32:19,120

rather nervous not very good at them

2690

01:32:23,430 --> 01:32:21,760

so well just so you know i'm extremely

2691

01:32:24,870 --> 01:32:23,440

nervous as well and partly one of the

2692

01:32:28,390 --> 01:32:24,880

reasons i have to go urinate is because

2693

01:32:31,750 --> 01:32:30,310

yeah i'm thinking how cut how calm and

2694

01:32:32,229 --> 01:32:31,760

professional you looked no i'm

2695

01:32:34,950 --> 01:32:32,239

absolutely

2696

01:32:36,790 --> 01:32:34,960

professional i appreciate that you would

2697

01:32:39,990 --> 01:32:36,800

even give me a modicum of that

2698

01:32:41,510 --> 01:32:40,000

i'm more i i'm much

2699

01:32:44,070 --> 01:32:41,520

i'm extremely introverted and i have

2700

01:32:45,830 --> 01:32:44,080

social anxiety it's just that i've

2701

01:32:47,830 --> 01:32:45,840

had to trade myself to overcome it to

2702

01:32:49,430 --> 01:32:47,840

some degree is everybody

2703

01:32:51,110 --> 01:32:49,440

faking it or there's some people who are

2704

01:32:52,310 --> 01:32:51,120

really extroverts

2705

01:32:54,149 --> 01:32:52,320

oh there are plenty of people who are

2706

01:32:56,070 --> 01:32:54,159

extroverts just so you know it was

2707

01:32:59,830 --> 01:32:56,080

somewhat ill-advised on my part to

2708

01:33:03,350 --> 01:32:59,840

speak to you because usually

2709

01:33:03,990 --> 01:33:03,360

i have i ask a professor can i speak

2710

01:33:05,590 --> 01:33:04,000

with you

2711

01:33:07,270 --> 01:33:05,600

six to eight weeks from now and then

2712

01:33:08,950 --> 01:33:07,280

they'll say yes or no and then i have

2713

01:33:11,910 --> 01:33:08,960

six to eight weeks to look up

2714

01:33:13,350 --> 01:33:11,920

their corpus of work and make notes and

2715

01:33:14,790 --> 01:33:13,360

and ask them somewhat

2716

01:33:17,270 --> 01:33:14,800

challenging questions or technical

2717

01:33:18,709 --> 01:33:17,280

questions for

2718

01:33:20,070 --> 01:33:18,719

furthering my understanding basically

2719

01:33:21,030 --> 01:33:20,080

trying to get in their head not trying

2720

01:33:22,790 --> 01:33:21,040

to disprove or

2721

01:33:24,149 --> 01:33:22,800

have a contentious interview at all just

2722

01:33:26,470 --> 01:33:24,159

trying to understand

2723

01:33:28,550 --> 01:33:26,480

and for this one i had i messaged you on

2724

01:33:31,750 --> 01:33:28,560

monday i believe you said yes on tuesday

2725

01:33:32,229 --> 01:33:31,760

and then i had one full day only this

2726

01:33:34,390 --> 01:33:32,239

week

2727

01:33:37,830 --> 01:33:34,400

to go through your entire work and i

2728

01:33:39,669 --> 01:33:37,840

could barely get through the

2729

01:33:41,510 --> 01:33:39,679

i can barely get through the overview of

2730

01:33:43,590 --> 01:33:41,520

the proof for the monstrous moonshine

2731

01:33:45,590 --> 01:33:43,600

conjecture i think you're way ahead of

2732

01:33:47,270 --> 01:33:45,600

most people on that

2733

01:33:49,189 --> 01:33:47,280

the surprise is not that it's hard to

2734

01:33:50,470 --> 01:33:49,199

understand the surprises that we can

2735

01:33:52,070 --> 01:33:50,480

understand it at all

2736

01:33:53,830 --> 01:33:52,080

i'm much more algebraic far more

2737

01:33:54,950 --> 01:33:53,840

algebraic than i am geometric and i

2738

01:33:57,270 --> 01:33:54,960

dislike when people

2739

01:33:58,870 --> 01:33:57,280

show group theory at first with the

2740

01:34:00,070 --> 01:33:58,880

rubik's cuber with the triangle

2741

01:34:01,830 --> 01:34:00,080

because to me i'm just thinking there

2742

01:34:02,229 --> 01:34:01,840

are far more symmetries than what you've

2743

01:34:03,669 --> 01:34:02,239

just

2744

01:34:05,910 --> 01:34:03,679

shown so someone will say the triangle

2745

01:34:06,870 --> 01:34:05,920

has six it may not may have eight i

2746

01:34:08,149 --> 01:34:06,880

don't know but whatever then i'm

2747

01:34:09,270 --> 01:34:08,159

thinking yeah but isn't there also the

2748

01:34:10,709 --> 01:34:09,280

symmetry of

2749

01:34:12,390 --> 01:34:10,719

let's say you invert the thickness of

2750

01:34:13,669 --> 01:34:12,400

the line and then bring it back so is

2751

01:34:15,110 --> 01:34:13,679

that not a symmetry

2752

01:34:16,629 --> 01:34:15,120

or is there not a symmetry of inverting

2753

01:34:17,510 --> 01:34:16,639

the colors and then bringing that like

2754

01:34:18,870 --> 01:34:17,520

why are you choosing

2755

01:34:20,790 --> 01:34:18,880

just just show me the axioms

2756

01:34:24,070 --> 01:34:20,800

algebraically i understand that

2757

01:34:27,430 --> 01:34:24,080

yeah well yeah

2758

01:34:30,229 --> 01:34:27,440

um yeah but i think i think that

2759

01:34:32,310 --> 01:34:30,239

it's a usual problem that you you can't

2760

01:34:34,149 --> 01:34:32,320

give a presentation of group theory that

2761

01:34:35,750 --> 01:34:34,159

satisfies everybody because people's

2762

01:34:37,669 --> 01:34:35,760

learning styles are so different some

2763

01:34:40,550 --> 01:34:37,679

want to see the axioms

2764

01:34:42,790 --> 01:34:40,560

some want to see examples and so on were

2765

01:34:46,709 --> 01:34:42,800

the questions okay

2766

01:34:48,390 --> 01:34:46,719

yeah except the ones where i

2767

01:34:50,149 --> 01:34:48,400

when i kind of got stressed out and

2768

01:34:52,470 --> 01:34:50,159

couldn't think what to say i mean

2769

01:34:54,390 --> 01:34:52,480

you know sometimes my i think there's

2770

01:34:55,910 --> 01:34:54,400

one weird one you're asking what what i

2771

01:34:58,149 --> 01:34:55,920

had been reading recently my brain just

2772

01:35:01,030 --> 01:34:58,159

completely froze

2773

01:35:01,430 --> 01:35:01,040

um yeah i find that happens for me as

2774

01:35:03,510 --> 01:35:01,440

well

2775

01:35:04,550 --> 01:35:03,520

you know no no no i think it i was

2776

01:35:06,629 --> 01:35:04,560

actually thinking about that

2777

01:35:08,229 --> 01:35:06,639

i'd read somewhere where where you know

2778

01:35:09,910 --> 01:35:08,239

someone was saying well that they'd ask

2779

01:35:10,709 --> 01:35:09,920

people what they're reading been reading

2780

01:35:12,310 --> 01:35:10,719

recently and

2781

01:35:14,070 --> 01:35:12,320

and some people were unable to answer

2782

01:35:16,070 --> 01:35:14,080

with a single book

2783

01:35:18,229 --> 01:35:16,080

as an example of how illiterate people

2784

01:35:19,910 --> 01:35:18,239

weren't i think to myself well

2785

01:35:21,270 --> 01:35:19,920

exactly the same is happening with me i

2786

01:35:22,790 --> 01:35:21,280

just can't think of anything i've

2787

01:35:23,830 --> 01:35:22,800

written in the part anything i've read

2788

01:35:27,270 --> 01:35:23,840

in the past day

2789

01:35:29,750 --> 01:35:27,280

i just couldn't think of anything at all

2790

01:35:31,189 --> 01:35:29,760

even though i've looked at several books

2791

01:35:32,229 --> 01:35:31,199

you know just hoping i didn't say

2792

01:35:34,229 --> 01:35:32,239

anything that's going to get me

2793

01:35:36,709 --> 01:35:34,239

condemned on the internet you know there

2794

01:35:38,229 --> 01:35:36,719

seem to be

2795

01:35:40,229 --> 01:35:38,239

too many cases of people who

2796

01:35:41,990 --> 01:35:40,239

inadvertently say something harmless

2797

01:35:44,229 --> 01:35:42,000

which turns out to be a code word for

2798

01:35:46,709 --> 01:35:44,239

some horrible crime see many

2799

01:35:48,149 --> 01:35:46,719

mathematicians physicists too

2800

01:35:49,910 --> 01:35:48,159

they have a difficult time with

2801
01:35:52,870 --> 01:35:49,920
answering questions that have to do with

2802
01:35:56,790 --> 01:35:52,880
that are ambiguous and yeah well me too

2803
01:35:58,470 --> 01:35:56,800
i mean you know whenever there was a

2804
01:36:01,030 --> 01:35:58,480
freezing up every now and then with uh

2805
01:36:03,830 --> 01:36:01,040
with with one of these

2806
01:36:04,790 --> 01:36:03,840
more more general questions right and i

2807
01:36:07,750 --> 01:36:04,800
would freeze up too

2808
01:36:08,790 --> 01:36:07,760
but the difference between me is that i

2809
01:36:10,310 --> 01:36:08,800
first

2810
01:36:11,750 --> 01:36:10,320
i have an artistic side that's the

2811
01:36:12,629 --> 01:36:11,760
filmmaking side that's the stand-up

2812
01:36:14,390 --> 01:36:12,639
comedy side

2813
01:36:17,350 --> 01:36:14,400

so in a sense that's almost like you're

2814

01:36:20,550 --> 01:36:17,360

you deal with ambiguity

2815

01:36:22,229 --> 01:36:20,560

as your regular male you so for me

2816

01:36:25,910 --> 01:36:22,239

i don't have too much of a problem with

2817

01:36:27,109 --> 01:36:25,920

it and it and i find that much of the

2818

01:36:29,270 --> 01:36:27,119

i don't know if you'll agree with this

2819

01:36:31,350 --> 01:36:29,280

but i've heard this said that much of

2820

01:36:33,669 --> 01:36:31,360

the pr much of the solution comes from

2821

01:36:37,109 --> 01:36:33,679

specifying the problem

2822

01:36:38,629 --> 01:36:37,119

and so i wonder how much of let's say

2823

01:36:40,149 --> 01:36:38,639

is an ant conscious or what is

2824

01:36:43,430 --> 01:36:40,159

consciousness and so on so on

2825

01:36:45,270 --> 01:36:43,440

how much of it is the solution

2826

01:36:46,550 --> 01:36:45,280

is just well how do we define it

2827

01:36:48,950 --> 01:36:46,560

properly

2828

01:36:50,950 --> 01:36:48,960

yeah well and this this seems to be the

2829

01:36:52,390 --> 01:36:50,960

cause of half the problems in philosophy

2830

01:36:55,830 --> 01:36:52,400

there they're arguing about something

2831

01:36:58,550 --> 01:36:55,840

that simply hasn't been properly defined

2832

01:36:59,270 --> 01:36:58,560

um possibly you could say the same about

2833

01:37:02,709 --> 01:36:59,280

religion

2834

01:37:05,990 --> 01:37:04,149

yeah and then some will even say that

2835

01:37:07,590 --> 01:37:06,000

par actually it's the opposite

2836

01:37:09,669 --> 01:37:07,600

the problem in religion is that people

2837

01:37:10,149 --> 01:37:09,679

are trying to define it and it should be

2838

01:37:14,709 --> 01:37:10,159

left

2839

01:37:18,310 --> 01:37:17,590

it's like me backing out of your

2840

01:37:19,990 --> 01:37:18,320

question about

2841

01:37:23,109 --> 01:37:20,000

god by saying i didn't know how it was

2842

01:37:26,950 --> 01:37:25,669

that's everyone that's every well that's

2843

01:37:29,189 --> 01:37:26,960

not everyone but that's most

2844

01:37:30,709 --> 01:37:29,199

mathematicians most physicists

2845

01:37:32,310 --> 01:37:30,719

and that would be me prior to two years

2846

01:37:35,030 --> 01:37:32,320

ago yeah so

2847

01:37:36,790 --> 01:37:35,040

well mathematicians actually trained to

2848

01:37:39,750 --> 01:37:36,800

have things well defined before you

2849

01:37:43,750 --> 01:37:39,760

start discussing them of course

2850

01:37:48,310 --> 01:37:46,070

sorry i wanted to speculate around that

2851

01:37:49,910 --> 01:37:48,320

because i wonder how much of it is

2852

01:37:51,669 --> 01:37:49,920

it's not that they don't like that it's

2853

01:37:54,149 --> 01:37:51,679

somewhat meaningless quote unquote

2854

01:37:55,590 --> 01:37:54,159

but that because it's meaningless

2855

01:37:56,950 --> 01:37:55,600

they're afraid that what they will say

2856

01:37:59,350 --> 01:37:56,960

will then be used against them

2857

01:38:00,870 --> 01:37:59,360

in some fool like oh you're imbecilic

2858

01:38:03,189 --> 01:38:00,880

for saying so and so

2859

01:38:04,070 --> 01:38:03,199

and it's more about the fear of

2860

01:38:07,189 --> 01:38:04,080

commenting

2861

01:38:09,270 --> 01:38:07,199

on what's vague and saying something

2862

01:38:11,270 --> 01:38:09,280

foolish than it is about commenting on

2863

01:38:12,870 --> 01:38:11,280

it at all and the reason why i say that

2864

01:38:14,629 --> 01:38:12,880

is because in our everyday life like i

2865

01:38:15,750 --> 01:38:14,639

mentioned to you we do use the word game

2866

01:38:17,510 --> 01:38:15,760

and chair and i

2867

01:38:19,109 --> 01:38:17,520

but those are actually ill-defined like

2868

01:38:20,870 --> 01:38:19,119

what is a chair maybe it's something to

2869

01:38:22,629 --> 01:38:20,880

sit on but then you get stumps

2870

01:38:23,910 --> 01:38:22,639

and then but what is i the more you look

2871

01:38:25,910 --> 01:38:23,920

at i what

2872

01:38:28,470 --> 01:38:25,920

what defines i and you you know there's

2873

01:38:30,709 --> 01:38:28,480

various well i i'd say everything is

2874

01:38:32,629 --> 01:38:30,719

ill-defined but but some things are more

2875

01:38:35,590 --> 01:38:32,639

ill-defined than others so

2876

01:38:37,189 --> 01:38:35,600

so chair i will normally know whether

2877

01:38:40,070 --> 01:38:37,199

something is a chair or not

2878

01:38:40,870 --> 01:38:40,080

um whereas something like god i just no

2879

01:38:43,990 --> 01:38:40,880

idea

2880

01:38:46,629 --> 01:38:44,000

um it's it's it's much i mean chair and

2881

01:38:49,109 --> 01:38:46,639

god may both be ill-defined but but

2882

01:38:50,629 --> 01:38:49,119

but but god is a lot more ill-defined

2883

01:38:52,709 --> 01:38:50,639

than chair

2884

01:38:54,870 --> 01:38:52,719

before we were talking about ramanujan

2885

01:38:56,470 --> 01:38:54,880

and you mentioned that when he

2886

01:38:58,310 --> 01:38:56,480

said that he got his ideas from his

2887

01:38:59,750 --> 01:38:58,320

prayers his visions meditations and so

2888

01:39:00,709 --> 01:38:59,760

on that probably he didn't he had a

2889

01:39:03,350 --> 01:39:00,719

secret mechanism

2890

01:39:03,910 --> 01:39:03,360

that he wasn't revealing and i'm curious

2891

01:39:06,229 --> 01:39:03,920

do you

2892

01:39:07,590 --> 01:39:06,239

have a secret technique to mathematics

2893

01:39:11,750 --> 01:39:07,600

that you don't reveal

2894

01:39:13,430 --> 01:39:11,760

uh no um and and i i don't know about

2895

01:39:17,350 --> 01:39:13,440

romantic either i'm just sort of

2896

01:39:21,750 --> 01:39:19,270

giving an answer to a slightly silly

2897

01:39:23,430 --> 01:39:21,760

question i mean it's it's

2898

01:39:25,189 --> 01:39:23,440

as i said it's just very difficult to

2899

01:39:28,070 --> 01:39:25,199

analyze your own mind and figure out

2900

01:39:29,510 --> 01:39:28,080

where ideas are coming from

2901

01:39:31,669 --> 01:39:29,520

what do you think would be the

2902

01:39:34,470 --> 01:39:31,679

implications that fermanagh did indeed

2903

01:39:37,669 --> 01:39:34,480

get his formulas inexplicably from his

2904

01:39:40,950 --> 01:39:37,679

visions and so on from a goddess or god

2905

01:39:44,550 --> 01:39:40,960

well i think that would just be his

2906

01:39:46,070 --> 01:39:44,560

explanation of explain what's going on

2907

01:39:48,709 --> 01:39:46,080

in his subconscious brain

2908

01:39:50,470 --> 01:39:48,719

i mean you here we call it subconscious

2909

01:39:53,990 --> 01:39:50,480

other cultures might call it

2910

01:39:55,910 --> 01:39:54,000

um a vision from a goddess i mean

2911

01:39:58,950 --> 01:39:55,920

but they're both ways of saying we have

2912

01:40:00,790 --> 01:39:58,960

no idea what's going on

2913

01:40:03,430 --> 01:40:00,800

you mentioned before that modular forms

2914

01:40:04,790 --> 01:40:03,440

are a field that you find to be the most

2915

01:40:07,270 --> 01:40:04,800

fascinating or provocative or

2916

01:40:08,550 --> 01:40:07,280

stimulating i don't recall which one of

2917

01:40:11,669 --> 01:40:08,560

those adjectives you used but

2918

01:40:14,790 --> 01:40:11,679

why is that the case um

2919

01:40:17,750 --> 01:40:14,800

well so so what modular forms do

2920

01:40:19,430 --> 01:40:17,760

is is they they they seem to turn up in

2921

01:40:19,830 --> 01:40:19,440

all sorts of areas of mathematics that

2922

01:40:21,430 --> 01:40:19,840

that

2923

01:40:22,950 --> 01:40:21,440

appear to have nothing to do with

2924

01:40:26,070 --> 01:40:22,960

modular forms

2925

01:40:27,510 --> 01:40:26,080

um obvious one i i used quite a lot was

2926

01:40:28,790 --> 01:40:27,520

they turn up in the theory of the

2927

01:40:30,470 --> 01:40:28,800

monster simple group and

2928

01:40:34,629 --> 01:40:30,480

simple groups seem to have nothing to do

2929

01:40:40,070 --> 01:40:38,229

marina via kovska um used them to

2930

01:40:42,790 --> 01:40:40,080

solve the sphere packing problem in high

2931

01:40:44,629 --> 01:40:42,800

dimensions and again that has

2932

01:40:46,149 --> 01:40:44,639

no obvious relation to modular forms

2933

01:40:47,510 --> 01:40:46,159

andrew wiles used them to

2934

01:40:49,270 --> 01:40:47,520

prove fermat's last theorem which

2935

01:40:50,310 --> 01:40:49,280

there's no obvious reason why they

2936

01:40:52,229 --> 01:40:50,320

should turn up so

2937

01:40:54,070 --> 01:40:52,239

they're turning up and completely

2938

01:40:56,950 --> 01:40:54,080

unexpectedly in all these

2939

01:40:58,470 --> 01:40:56,960

completely separate mathematical areas

2940

01:41:01,109 --> 01:40:58,480

and whenever they turn up

2941

01:41:02,149 --> 01:41:01,119

all these utterly bizarre coincidences

2942

01:41:06,950 --> 01:41:02,159

start happening

2943

01:41:09,109 --> 01:41:06,960

i mean in order for modular forms to

2944

01:41:11,590 --> 01:41:09,119

solve a problem you need a whole chain

2945

01:41:13,750 --> 01:41:11,600

of bizarre numerical coincidences and

2946

01:41:17,510 --> 01:41:13,760

these numerical bizarre coincidences

2947

01:41:19,510 --> 01:41:17,520

often seem to happen um so

2948

01:41:20,870 --> 01:41:19,520

you know that there's there's something

2949

01:41:24,629 --> 01:41:20,880

very weird going on

2950

01:41:27,109 --> 01:41:24,639

um as to why modular forms turn up

2951

01:41:31,350 --> 01:41:27,119

in all these places i just have no idea

2952

01:41:34,390 --> 01:41:32,709

is one of those connections those

2953

01:41:36,390 --> 01:41:34,400

coincidences the one nine six

2954

01:41:37,430 --> 01:41:36,400

eight eight three yeah yeah yeah exactly

2955

01:41:39,270 --> 01:41:37,440

so there's this

2956

01:41:41,669 --> 01:41:39,280

that that's a typical example of this

2957

01:41:43,669 --> 01:41:41,679

bizarre numerical coincidence you

2958

01:41:45,510 --> 01:41:43,679

you take a representation of the monster

2959

01:41:48,070 --> 01:41:45,520

group and it happens to be

2960

01:41:52,629 --> 01:41:48,080

almost the same as a coefficient of the

2961

01:41:56,149 --> 01:41:54,709

okay now i'm going to read to you a

2962

01:41:57,189 --> 01:41:56,159

thought from another mathematician i

2963

01:41:58,950 --> 01:41:57,199

recall you saying that you believe

2964

01:42:00,709 --> 01:41:58,960

mathematics is discovered

2965

01:42:02,070 --> 01:42:00,719

and he says it's invented and i don't

2966

01:42:02,950 --> 01:42:02,080

know which mathematician this is so

2967

01:42:04,709 --> 01:42:02,960

don't worry

2968

01:42:06,470 --> 01:42:04,719

this is an anonymous mathematician he

2969

01:42:08,470 --> 01:42:06,480

says mathematics is created because it's

2970

01:42:09,910 --> 01:42:08,480

a language used by humans so that we can

2971

01:42:10,550 --> 01:42:09,920

understand and make sense of the world

2972

01:42:12,709 --> 01:42:10,560

around us

2973

01:42:13,750 --> 01:42:12,719

for mathematics to be discovered you

2974

01:42:15,510 --> 01:42:13,760

would assume

2975

01:42:17,270 --> 01:42:15,520

that the way humans perceive the world

2976

01:42:18,950 --> 01:42:17,280

is absolute truth and in

2977

01:42:20,470 --> 01:42:18,960

some way establish humans as the

2978

01:42:22,870 --> 01:42:20,480

universal standard

2979

01:42:24,390 --> 01:42:22,880

of everything i might be rambling here

2980

01:42:25,750 --> 01:42:24,400

but i get the feeling that if you choose

2981

01:42:27,510 --> 01:42:25,760

to see mathematics

2982

01:42:30,550 --> 01:42:27,520

as something that was discovered by

2983

01:42:32,790 --> 01:42:30,560

mankind you are taking a human-centric

2984

01:42:34,550 --> 01:42:32,800

and deterministic view on the universe

2985

01:42:35,030 --> 01:42:34,560

we only created it to make sense of

2986

01:42:37,030 --> 01:42:35,040

things

2987

01:42:38,790 --> 01:42:37,040

just like we created the spoken word to

2988

01:42:39,270 --> 01:42:38,800

communicate so what are your thoughts on

2989

01:42:43,189 --> 01:42:39,280

that

2990

01:42:45,109 --> 01:42:43,199

rambling as he suspects

2991

01:42:46,310 --> 01:42:45,119

um the point about mathematics is

2992

01:42:48,470 --> 01:42:46,320

suppose there's a

2993

01:42:51,270 --> 01:42:48,480

another civilization on say alpha

2994

01:42:53,830 --> 01:42:51,280

century

2995

01:42:55,030 --> 01:42:53,840

and they will have the same mathematics

2996

01:42:56,310 --> 01:42:55,040

that we do i mean that

2997

01:42:58,550 --> 01:42:56,320

obviously they won't use the same

2998

01:42:59,189 --> 01:42:58,560

notation or terminology in the same way

2999

01:43:01,270 --> 01:42:59,199

that

3000

01:43:03,189 --> 01:43:01,280

you know english and french people do

3001

01:43:04,709 --> 01:43:03,199

the same mathematics but they do it in a

3002

01:43:06,470 --> 01:43:04,719

different language so they will

3003

01:43:08,070 --> 01:43:06,480

they will have the same mathematical

3004

01:43:10,229 --> 01:43:08,080

theorems

3005

01:43:11,669 --> 01:43:10,239

expressed in their own weird language

3006

01:43:12,950 --> 01:43:11,679

and they will have found the monster

3007

01:43:14,550 --> 01:43:12,960

simple group and they will have found

3008

01:43:16,070 --> 01:43:14,560

modular forms and they will have found

3009

01:43:19,430 --> 01:43:16,080

everything else

3010

01:43:21,030 --> 01:43:19,440

so it's not a human centric way of

3011

01:43:22,709 --> 01:43:21,040

viewing the world it's a universal way

3012

01:43:24,149 --> 01:43:22,719

of viewing the world

3013

01:43:25,750 --> 01:43:24,159

i mean at least that's why i think maybe

3014

01:43:29,510 --> 01:43:25,760

it's me who's rambling but

3015

01:43:31,430 --> 01:43:29,520

um i i would say it's disgus it's it's

3016

01:43:33,350 --> 01:43:31,440

discovered not invented because any

3017

01:43:35,510 --> 01:43:33,360

other advanced civilization will have an

3018

01:43:37,109 --> 01:43:35,520

equivalent mathematics

3019

01:43:40,229 --> 01:43:37,119

do you think that we'd share an idea of

3020

01:43:43,350 --> 01:43:40,239

what the few key theorems are

3021

01:43:47,590 --> 01:43:45,910

the book it it it's it's a very

3022

01:43:49,590 --> 01:43:47,600

speculative question that

3023

01:43:51,510 --> 01:43:49,600

this is in some sense meaningless but in

3024

01:43:53,350 --> 01:43:51,520

spite of that i will say yes i i would

3025

01:43:54,149 --> 01:43:53,360

guess that other advanced civilizations

3026

01:43:56,790 --> 01:43:54,159

will on the whole

3027

01:43:58,470 --> 01:43:56,800

share the same key theories maybe not

3028

01:44:01,270 --> 01:43:58,480

exactly but

3029

01:44:03,109 --> 01:44:01,280

um let me be more explicit as to what i

3030

01:44:06,870 --> 01:44:03,119

mean

3031

01:44:07,590 --> 01:44:06,880

that they would have the same idea as

3032

01:44:10,709 --> 01:44:07,600

that

3033

01:44:12,550 --> 01:44:10,719

they would share the same theorems it

3034

01:44:14,390 --> 01:44:12,560

might just be one line as a lemma but we

3035

01:44:15,830 --> 01:44:14,400

consider it to be a holy grail

3036

01:44:18,229 --> 01:44:15,840

and they would also consider it to be

3037

01:44:20,310 --> 01:44:18,239

something of i think there'd be a a lot

3038

01:44:20,870 --> 01:44:20,320

of overlap i mean i mean even between

3039

01:44:24,070 --> 01:44:20,880

different

3040

01:44:26,629 --> 01:44:24,080

mathematical um

3041

01:44:27,750 --> 01:44:26,639

i mean before the world sort of became

3042

01:44:31,350 --> 01:44:27,760

unified there were dif

3043

01:44:31,750 --> 01:44:31,360

different mathematical um cultures like

3044

01:44:33,910 --> 01:44:31,760

the

3045

01:44:35,030 --> 01:44:33,920

greeks and indians and japanese all had

3046

01:44:36,229 --> 01:44:35,040

slightly different approaches to

3047

01:44:37,990 --> 01:44:36,239

mathematics and they

3048

01:44:39,669 --> 01:44:38,000

they weren't exactly the same on what

3049

01:44:41,189 --> 01:44:39,679

they agreed were the

3050

01:44:42,950 --> 01:44:41,199

central theorems or approaches of the

3051
01:44:44,310 --> 01:44:42,960
subject but there was there was a lot of

3052
01:44:46,229 --> 01:44:44,320
overlap

3053
01:44:47,350 --> 01:44:46,239
yeah recall someone's estimation for pi

3054
01:44:50,149 --> 01:44:47,360
was four

3055
01:44:51,109 --> 01:44:50,159
i don't recall which time uh spatial

3056
01:44:53,270 --> 01:44:51,119
location

3057
01:44:54,870 --> 01:44:53,280
yes there'd been some very weird

3058
01:44:58,070 --> 01:44:54,880
estimates for pi

3059
01:45:00,830 --> 01:44:58,080
okay so tori ko says what does he enjoy

3060
01:45:03,750 --> 01:45:00,840
or find meaningful about math

3061
01:45:07,109 --> 01:45:03,760
uh

3062
01:45:10,470 --> 01:45:07,119
well i i like it because because it's

3063
01:45:12,709 --> 01:45:10,480

it's really describing how the universe

3064

01:45:13,109 --> 01:45:12,719

works in some very fundamental way i

3065

01:45:16,070 --> 01:45:13,119

mean

3066

01:45:17,990 --> 01:45:16,080

um as i think i mentioned earlier the

3067

01:45:20,229 --> 01:45:18,000

universe seems to be

3068

01:45:21,830 --> 01:45:20,239

running on mathematics in some very deep

3069

01:45:24,070 --> 01:45:21,840

sense that

3070

01:45:26,310 --> 01:45:24,080

you know physics like the standard model

3071

01:45:29,510 --> 01:45:26,320

or general relativity

3072

01:45:31,430 --> 01:45:29,520

is is really just an application of

3073

01:45:33,189 --> 01:45:31,440

mathematics

3074

01:45:34,950 --> 01:45:33,199

so when you're discovering something new

3075

01:45:36,550 --> 01:45:34,960

in mathematics you can think of it as

3076

01:45:40,310 --> 01:45:36,560

being discovering something new about

3077

01:45:43,990 --> 01:45:42,470

so to me when you say that if i didn't

3078

01:45:44,950 --> 01:45:44,000

have any context as to who you were i

3079

01:45:46,629 --> 01:45:44,960

would have thought you were either a

3080

01:45:50,149 --> 01:45:46,639

theoretical physicist or a physicist

3081

01:45:50,470 --> 01:45:50,159

in some capacity why is it do you think

3082

01:45:53,669 --> 01:45:50,480

that

3083

01:45:55,350 --> 01:45:53,679

math somehow has a more direct access to

3084

01:45:59,750 --> 01:45:55,360

the

3085

01:46:02,870 --> 01:45:59,760

no i mean

3086

01:46:03,750 --> 01:46:02,880

mathematics has access to the way the

3087

01:46:05,510 --> 01:46:03,760

universe works

3088

01:46:07,189 --> 01:46:05,520

through theoretical physics i mean

3089

01:46:08,870 --> 01:46:07,199

theoretical physics is the interface

3090

01:46:11,910 --> 01:46:08,880

between mathematics and the

3091

01:46:12,629 --> 01:46:11,920

actual physical world in some sense i

3092

01:46:14,229 --> 01:46:12,639

mean not

3093

01:46:15,910 --> 01:46:14,239

not all mathematics seems to have a

3094

01:46:17,430 --> 01:46:15,920

direct relation to the physical world i

3095

01:46:19,669 --> 01:46:17,440

mean that no one's found the monster

3096

01:46:21,750 --> 01:46:19,679

simple group in in

3097

01:46:23,669 --> 01:46:21,760

in in in our four-dimensional universe

3098

01:46:27,350 --> 01:46:23,679

yet but um

3099

01:46:30,390 --> 01:46:27,360

there's there's a lot of overlap i mean

3100

01:46:32,149 --> 01:46:30,400

um it's it's quite

3101

01:46:33,830 --> 01:46:32,159

hard to find an area of mathematics

3102

01:46:37,350 --> 01:46:33,840

which has nothing whatsoever to do with

3103

01:46:41,830 --> 01:46:38,709

what type of mathematician would you

3104

01:46:44,229 --> 01:46:41,840

consider yourself a pure mathematician

3105

01:46:45,590 --> 01:46:44,239

if you have to divide mathematicians up

3106

01:46:47,510 --> 01:46:45,600

like that then i guess i

3107

01:46:49,270 --> 01:46:47,520

count as pure rather than rather than

3108

01:46:52,070 --> 01:46:49,280

applied or a physicist

3109

01:46:53,910 --> 01:46:52,080

i mean i as i said i i sort of tried

3110

01:46:55,350 --> 01:46:53,920

doing theoretical physics a bit and that

3111

01:46:58,870 --> 01:46:55,360

didn't work out so well

3112

01:47:00,550 --> 01:46:58,880

so um is that the only reason why you

3113

01:47:01,990 --> 01:47:00,560

abandoned theoretical physics in favor

3114

01:47:03,830 --> 01:47:02,000

of pure mathematics because

3115

01:47:05,350 --> 01:47:03,840

you just had a difficult time or is that

3116

01:47:08,550 --> 01:47:05,360

something that seems to be a perfectly

3117

01:47:11,910 --> 01:47:08,560

good reason for abandoning something

3118

01:47:13,910 --> 01:47:11,920

um yeah harris chandra apparently did

3119

01:47:15,750 --> 01:47:13,920

the same he started off as a theoretical

3120

01:47:16,390 --> 01:47:15,760

physicist and switched to mathematics

3121

01:47:22,149 --> 01:47:16,400

because

3122

01:47:25,270 --> 01:47:22,159

he he found it too difficult

3123

01:47:26,709 --> 01:47:25,280

terry co torical the same person says

3124

01:47:28,470 --> 01:47:26,719

what does he think about biology

3125

01:47:32,070 --> 01:47:28,480

psychology philosophy

3126

01:47:32,870 --> 01:47:32,080

do you think that you would gain as much

3127

01:47:37,350 --> 01:47:32,880

of a sense of

3128

01:47:40,070 --> 01:47:37,360

understanding by exploring those fields

3129

01:47:41,669 --> 01:47:40,080

um well again i have the caveat that i

3130

01:47:42,310 --> 01:47:41,679

don't actually know a lot about these

3131

01:47:45,590 --> 01:47:42,320

fields

3132

01:47:47,510 --> 01:47:45,600

um biology i tried reading some biology

3133

01:47:51,109 --> 01:47:47,520

textbooks and they're incredibly

3134

01:47:53,669 --> 01:47:51,119

scary and you read a biology book on the

3135

01:47:55,830 --> 01:47:53,679

way that a cell works for example and

3136

01:47:57,510 --> 01:47:55,840

it's perfectly obvious that a cell can't

3137

01:47:58,310 --> 01:47:57,520

possibly work in the way it describes

3138

01:48:01,830 --> 01:47:58,320

it's just so

3139

01:48:03,669 --> 01:48:01,840

complicated that that um

3140

01:48:05,430 --> 01:48:03,679

the way cells work is so complicated and

3141

01:48:05,830 --> 01:48:05,440

bizarre it's very hard to believe to

3142

01:48:07,750 --> 01:48:05,840

exist

3143

01:48:08,950 --> 01:48:07,760

i'm sort of worried that if i if i read

3144

01:48:10,870 --> 01:48:08,960

a biology book

3145

01:48:12,229 --> 01:48:10,880

you know the universe will suddenly

3146

01:48:13,830 --> 01:48:12,239

catch up with this and i'll drop

3147

01:48:16,709 --> 01:48:13,840

dead so i think biology is a bit

3148

01:48:20,790 --> 01:48:16,719

dangerous to study because it seems so

3149

01:48:23,590 --> 01:48:20,800

so incredible also just so much of it

3150

01:48:25,830 --> 01:48:23,600

i mean i i just hadn't quite dawned on

3151
01:48:29,590 --> 01:48:25,840
me and just how horrifically complicated

3152
01:48:31,350 --> 01:48:29,600
cells are timber finn says

3153
01:48:32,550 --> 01:48:31,360
is nature fundamentally mathematical or

3154
01:48:33,350 --> 01:48:32,560
something else now i know you touched on

3155
01:48:36,629 --> 01:48:33,360
this but

3156
01:48:38,709 --> 01:48:36,639
again for timber finn well

3157
01:48:40,390 --> 01:48:38,719
depends what you mean by fundamentally

3158
01:48:42,310 --> 01:48:40,400
um i would say if you go

3159
01:48:43,990 --> 01:48:42,320
deep enough into anything you eventually

3160
01:48:45,990 --> 01:48:44,000
get to mathematics i mean you

3161
01:48:48,229 --> 01:48:46,000
you might start with you know trying to

3162
01:48:49,189 --> 01:48:48,239
understand nature via biology and if you

3163
01:48:50,910 --> 01:48:49,199

look really

3164

01:48:52,229 --> 01:48:50,920

deep into biology you find it's really

3165

01:48:53,590 --> 01:48:52,239

biochemistry

3166

01:48:55,510 --> 01:48:53,600

and if you're trying to work out how all

3167

01:48:57,109 --> 01:48:55,520

these biochemical molecules work you

3168

01:48:58,629 --> 01:48:57,119

discover it's really quantum mechanics

3169

01:49:00,149 --> 01:48:58,639

which is physics and if you look at how

3170

01:49:01,830 --> 01:49:00,159

physics works you suddenly find you're

3171

01:49:04,870 --> 01:49:01,840

down to mathematics

3172

01:49:08,870 --> 01:49:04,880

so mathematics is sort of at the core of

3173

01:49:13,350 --> 01:49:11,189

bernardo fitzpatrick asks i would like

3174

01:49:15,830 --> 01:49:13,360

to know does the professor

3175

01:49:17,350 --> 01:49:15,840

know of italian mathematician dr olivia

3176

01:49:19,510 --> 01:49:17,360

carmelo

3177

01:49:21,270 --> 01:49:19,520

and if so what does he think of her use

3178

01:49:23,270 --> 01:49:21,280

of alexander garthande

3179

01:49:24,709 --> 01:49:23,280

tawpos's as a unifying theory in

3180

01:49:27,270 --> 01:49:24,719

mathematics

3181

01:49:28,870 --> 01:49:27,280

and her interpretation of tapas's or

3182

01:49:31,750 --> 01:49:28,880

topoi as bridges

3183

01:49:33,109 --> 01:49:31,760

in order to facilitate this unification

3184

01:49:35,750 --> 01:49:33,119

well i i

3185

01:49:38,950 --> 01:49:35,760

don't don't remember the name off-hand

3186

01:49:41,910 --> 01:49:38,960

but toplesses have indeed been used as a

3187

01:49:42,950 --> 01:49:41,920

um unifying thing in mathematics so

3188

01:49:44,790 --> 01:49:42,960

topos is this

3189

01:49:45,990 --> 01:49:44,800

construction that alexander grothenbeck

3190

01:49:47,669 --> 01:49:46,000

came up with

3191

01:49:49,430 --> 01:49:47,679

and it was shortly afterwards realized

3192

01:49:52,629 --> 01:49:49,440

by law vera i think that

3193

01:49:53,350 --> 01:49:52,639

toppos was really a sort of almost a

3194

01:49:56,229 --> 01:49:53,360

sort of

3195

01:49:58,149 --> 01:49:56,239

intuitionistic model of set theory or or

3196

01:50:01,030 --> 01:49:58,159

a weak version of set theory

3197

01:50:02,709 --> 01:50:01,040

so you can in fact do most mathematics

3198

01:50:06,229 --> 01:50:02,719

inside

3199

01:50:08,470 --> 01:50:06,239

a suitable topos and in fact this is

3200

01:50:10,390 --> 01:50:08,480

this is almost one theme of growth index

3201

01:50:11,030 --> 01:50:10,400

algebraic geometry that anything you can

3202

01:50:14,870 --> 01:50:11,040

do

3203

01:50:17,109 --> 01:50:14,880

an arbitrary topos and that that gives

3204

01:50:21,750 --> 01:50:17,119

you a sort of

3205

01:50:27,030 --> 01:50:24,629

does he have an opinion on grothen dick

3206

01:50:28,149 --> 01:50:27,040

um i'm just overwhelmed by him i mean i

3207

01:50:29,589 --> 01:50:28,159

i just

3208

01:50:31,350 --> 01:50:29,599

i mean that there are a lot of great

3209

01:50:33,750 --> 01:50:31,360

mathematicians i sort of think

3210

01:50:35,589 --> 01:50:33,760

well you know i i could have proved that

3211

01:50:37,270 --> 01:50:35,599

guy's theorem if i'd just been a bit

3212

01:50:37,990 --> 01:50:37,280

smarter or worked a bit harder and then

3213

01:50:39,589 --> 01:50:38,000

there are

3214

01:50:41,669 --> 01:50:39,599

other mathematicians i look at their

3215

01:50:43,830 --> 01:50:41,679

work and i realize there's just

3216

01:50:46,149 --> 01:50:43,840

no way i could possibly have done that

3217

01:50:47,830 --> 01:50:46,159

no matter how hard i worked and

3218

01:50:49,510 --> 01:50:47,840

you know growth and dick's one of them

3219

01:50:51,669 --> 01:50:49,520

and you know there are a few others like

3220

01:50:53,669 --> 01:50:51,679

john thompson's work on finite groups i

3221

01:50:56,470 --> 01:50:53,679

could just never have done and

3222

01:50:58,470 --> 01:50:56,480

andrew wiles's work on firma's last him

3223

01:51:01,189 --> 01:50:58,480

i just couldn't possibly have done so

3224

01:51:02,149 --> 01:51:01,199

so he's one of the ones who just i have

3225

01:51:03,990 --> 01:51:02,159

to admit they're just

3226

01:51:07,910 --> 01:51:04,000

way out of reach of anything i could

3227

01:51:11,510 --> 01:51:07,920

ever have done have you met wiles

3228

01:51:15,030 --> 01:51:11,520

very briefly once or twice

3229

01:51:17,510 --> 01:51:15,040

okay many people this comes from per

3230

01:51:19,430 --> 01:51:17,520

peridot many people decide that they're

3231

01:51:20,550 --> 01:51:19,440

more analytical than algebraic or vice

3232

01:51:22,550 --> 01:51:20,560

versa

3233

01:51:23,990 --> 01:51:22,560

can he expound on a bit on why he

3234

01:51:25,669 --> 01:51:24,000

personally finds inequalities

3235

01:51:27,109 --> 01:51:25,679

unappealing as opposed to equalities

3236

01:51:28,790 --> 01:51:27,119

this goes back to our

3237

01:51:30,149 --> 01:51:28,800

previous conversation they're not

3238

01:51:32,390 --> 01:51:30,159

unappealing i like

3239

01:51:34,390 --> 01:51:32,400

inequalities it's just that you know i

3240

01:51:36,870 --> 01:51:34,400

just don't

3241

01:51:37,750 --> 01:51:36,880

what's the word um they're too messy i

3242

01:51:39,990 --> 01:51:37,760

just haven't got them

3243

01:51:41,910 --> 01:51:40,000

completely internalized i i i don't have

3244

01:51:44,870 --> 01:51:41,920

a good feeling for them

3245

01:51:46,070 --> 01:51:44,880

um the reason for this i i don't know i

3246

01:51:48,070 --> 01:51:46,080

think i just

3247

01:51:50,070 --> 01:51:48,080

it's probably just a matter of practice

3248

01:51:52,790 --> 01:51:50,080

i spent a lot more time working

3249

01:51:53,830 --> 01:51:52,800

thinking about algebra and equalities

3250

01:51:55,510 --> 01:51:53,840

and so on and

3251

01:51:57,830 --> 01:51:55,520

presumably if i'd spend all that time

3252

01:51:59,910 --> 01:51:57,840

thinking about inequalities i would

3253

01:52:01,589 --> 01:51:59,920

be the other way around i mean i i think

3254

01:52:03,750 --> 01:52:01,599

the difference between

3255

01:52:05,589 --> 01:52:03,760

mathematicians who are more algebra and

3256

01:52:08,790 --> 01:52:05,599

mathematicians who are more analysis

3257

01:52:12,149 --> 01:52:08,800

is is is very much what they spent most

3258

01:52:16,950 --> 01:52:14,229

and the last one is from the same person

3259

01:52:17,589 --> 01:52:16,960

peridot he says for the abc conjecture

3260

01:52:19,350 --> 01:52:17,599

question

3261

01:52:21,990 --> 01:52:19,360

can you please allow him to be as super

3262

01:52:23,189 --> 01:52:22,000

detailed as he's as he possibly can be

3263

01:52:25,669 --> 01:52:23,199

and if he says he doesn't know much

3264

01:52:27,189 --> 01:52:25,679

about it ask him what why he thinks it

3265

01:52:28,870 --> 01:52:27,199

hasn't triggered his curiosity i'm

3266

01:52:30,149 --> 01:52:28,880

assuming there was a previous abc

3267

01:52:30,870 --> 01:52:30,159

conjecture question but i can only

3268

01:52:33,990 --> 01:52:30,880

conjecture

3269

01:52:36,470 --> 01:52:34,000

about so let's say

3270

01:52:38,229 --> 01:52:36,480

his last sentence says i am consistently

3271

01:52:39,990 --> 01:52:38,239

curious about the process of how

3272

01:52:40,790 --> 01:52:40,000

mathematicians decide what is and isn't

3273

01:52:42,550 --> 01:52:40,800

worth their time

3274

01:52:44,149 --> 01:52:42,560

from a mathematical perspective so i

3275

01:52:45,669 --> 01:52:44,159

assume he's wondering why haven't you

3276

01:52:46,870 --> 01:52:45,679

tackled the abc conjecture and why do

3277

01:52:48,790 --> 01:52:46,880

you choose this topic

3278

01:52:51,109 --> 01:52:48,800

rather than this one well i don't have

3279

01:52:52,470 --> 01:52:51,119

your interest i haven't tackled the abc

3280

01:52:55,270 --> 01:52:52,480

conjecture because it's just too

3281

01:52:57,109 --> 01:52:55,280

difficult i mean you you have to

3282

01:52:58,310 --> 01:52:57,119

select problems that there's some hope

3283

01:53:00,790 --> 01:52:58,320

of making progress

3284

01:53:03,189 --> 01:53:00,800

in um if you're asking about my opinions

3285

01:53:05,990 --> 01:53:03,199

of machu zuki's work well

3286

01:53:06,790 --> 01:53:06,000

i just have no idea i i think i said

3287

01:53:08,550 --> 01:53:06,800

earlier i

3288

01:53:10,790 --> 01:53:08,560

tried to understand it for a few hours

3289

01:53:11,430 --> 01:53:10,800

and it was became obvious to me that it

3290

01:53:14,790 --> 01:53:11,440

would take me

3291

01:53:16,629 --> 01:53:14,800

many years of study to get a vague idea

3292

01:53:19,830 --> 01:53:16,639

of what was going on

3293

01:53:21,669 --> 01:53:19,840

um so yeah yeah so so mochizuki's

3294

01:53:24,709 --> 01:53:21,679

another one of these guys

3295

01:53:26,790 --> 01:53:24,719

who look at his work and there's just

3296

01:53:28,470 --> 01:53:26,800

no way i would have been able to to do

3297

01:53:30,950 --> 01:53:28,480

that i mean i

3298

01:53:32,229 --> 01:53:30,960

i i mean it's a bit controversial about

3299

01:53:33,910 --> 01:53:32,239

whether it's right or wrong at the

3300

01:53:35,510 --> 01:53:33,920

moment of course but

3301

01:53:38,709 --> 01:53:35,520

you know whether it's right or wrong

3302

01:53:40,790 --> 01:53:38,719

it's still an an incredible

3303

01:53:44,310 --> 01:53:40,800

uh mochizuki's work is still an

3304

01:53:47,910 --> 01:53:45,910

and how do you decide what's worth your

3305

01:53:49,669 --> 01:53:47,920

time and what's not from a mathematical

3306

01:53:52,070 --> 01:53:49,679

perspective

3307

01:53:54,310 --> 01:53:52,080

um if it works it's worth my time and if

3308

01:53:56,390 --> 01:53:54,320

it doesn't work it's not worth my time

3309

01:53:58,229 --> 01:53:56,400

you you you can't tell in advance you

3310

01:54:01,109 --> 01:53:58,239

just have to

3311

01:54:01,990 --> 01:54:01,119

if there's a problem or area you start

3312

01:54:05,109 --> 01:54:02,000

working on it

3313

01:54:07,430 --> 01:54:05,119

and sometimes it just doesn't seem to be

3314

01:54:10,950 --> 01:54:07,440

working out and sometimes it does

3315

01:54:12,470 --> 01:54:10,960

and deciding what is worth your time is

3316

01:54:15,270 --> 01:54:12,480

actually one of the hardest problems in

3317

01:54:17,270 --> 01:54:15,280

mathematics because

3318

01:54:18,870 --> 01:54:17,280

you you know you you may have spent

3319

01:54:20,470 --> 01:54:18,880

several months working on a problem

3320

01:54:21,910 --> 01:54:20,480

maybe you're just about to make a

3321

01:54:23,510 --> 01:54:21,920

breakthrough and if you only spent

3322

01:54:23,830 --> 01:54:23,520

another week on it then you would crack

3323

01:54:27,270 --> 01:54:23,840

it

3324

01:54:28,550 --> 01:54:27,280

but you can't tell maybe you know

3325

01:54:30,390 --> 01:54:28,560

maybe it's a week away from being

3326

01:54:32,149 --> 01:54:30,400

cracked maybe you could spend another 10

3327

01:54:34,629 --> 01:54:32,159

years on it without getting anywhere

3328

01:54:37,350 --> 01:54:34,639

and if you could tell which that this

3329

01:54:39,430 --> 01:54:37,360

would make research so much easier

3330

01:54:42,310 --> 01:54:39,440

so it's really one of the biggest

3331

01:54:45,669 --> 01:54:42,320

problems in research is is figuring out

3332

01:54:49,030 --> 01:54:45,679

um which

3333

01:54:50,870 --> 01:54:49,040

which approaches are likely to work

3334

01:54:52,470 --> 01:54:50,880

how many weeks or months do you usually

3335

01:54:53,430 --> 01:54:52,480

give on a problem before you decide it's

3336

01:54:56,310 --> 01:54:53,440

solvable or not

3337

01:54:56,870 --> 01:54:56,320

by you well i never really give up on

3338

01:54:59,669 --> 01:54:56,880

problems

3339

01:55:01,430 --> 01:54:59,679

what what what you do is you you work on

3340

01:55:02,629 --> 01:55:01,440

problems for a bit and then you

3341

01:55:03,830 --> 01:55:02,639

get a bit depressed because you're

3342

01:55:05,669 --> 01:55:03,840

getting nowhere and then you put it

3343

01:55:08,790 --> 01:55:05,679

aside but

3344

01:55:10,149 --> 01:55:08,800

always come back to it later after a few

3345

01:55:12,310 --> 01:55:10,159

months or years when

3346

01:55:14,390 --> 01:55:12,320

when you i mean what generally happens

3347

01:55:16,709 --> 01:55:14,400

is i i i forget

3348

01:55:18,229 --> 01:55:16,719

why my approach didn't work and and a

3349

01:55:19,990 --> 01:55:18,239

few years later i think oh why doesn't

3350

01:55:20,550 --> 01:55:20,000

this approach work and i try it again

3351

01:55:22,070 --> 01:55:20,560

and then

3352

01:55:24,470 --> 01:55:22,080

then i discover why it doesn't work

3353

01:55:26,070 --> 01:55:24,480

again but but every now and then you

3354

01:55:28,470 --> 01:55:26,080

you you make a little bit of extra

3355

01:55:30,229 --> 01:55:28,480

progress and

3356

01:55:31,830 --> 01:55:30,239

sometimes after coming back to the

3357

01:55:34,390 --> 01:55:31,840

problem dozen

3358

01:55:35,830 --> 01:55:34,400

times you finally managed to solve it

3359

01:55:37,510 --> 01:55:35,840

and there are plenty of other problems

3360

01:55:40,470 --> 01:55:37,520

i've come back to many times

3361

01:55:41,669 --> 01:55:40,480

and that i'm still stuck on them how

3362

01:55:43,350 --> 01:55:41,679

come you forgot

3363

01:55:45,189 --> 01:55:43,360

that you tried a certain technique and

3364

01:55:46,550 --> 01:55:45,199

it didn't work because i would imagine

3365

01:55:48,550 --> 01:55:46,560

you take notes

3366

01:55:49,830 --> 01:55:48,560

and you would have to take notes taking

3367

01:55:53,030 --> 01:55:49,840

notes i mean

3368

01:55:55,990 --> 01:55:53,040

it requires being organized i'm i i i'm

3369

01:55:58,149 --> 01:55:56,000

very bad at keeping notes of what i do

3370

01:56:00,070 --> 01:55:58,159

i mean i mean scrapbooks of your work no

3371

01:56:02,310 --> 01:56:00,080

well i tried keeping a scrapbook of some

3372

01:56:03,830 --> 01:56:02,320

of my work and i and i looked at it a

3373

01:56:05,589 --> 01:56:03,840

couple of years later it was completely

3374

01:56:07,109 --> 01:56:05,599

illegible and i couldn't figure out what

3375

01:56:10,390 --> 01:56:07,119

on earth i was talking about because i'd

3376

01:56:13,510 --> 01:56:10,400

been too lazy to write up proper notes

3377

01:56:15,510 --> 01:56:13,520

and yeah and it may not be a bad idea to

3378

01:56:17,030 --> 01:56:15,520

sort of forget what the problem was and

3379

01:56:18,790 --> 01:56:17,040

come back to it because sometimes when

3380

01:56:19,910 --> 01:56:18,800

you come back to it you suddenly realize

3381

01:56:23,189 --> 01:56:19,920

that the

3382

01:56:25,030 --> 01:56:23,199

thing you were stuck on it wasn't really

3383

01:56:26,790 --> 01:56:25,040

valid and there's a way around it

3384

01:56:29,350 --> 01:56:26,800

of course most of the time it was valid

3385

01:56:30,629 --> 01:56:29,360

but whatever

3386

01:56:33,189 --> 01:56:30,639

you know i had a note and it's just a

3387

01:56:33,830 --> 01:56:33,199

bullet point it said no ghost theorem

3388

01:56:35,589 --> 01:56:33,840

and it

3389

01:56:36,950 --> 01:56:35,599

reminded me i wanted to ask you if you

3390

01:56:38,709 --> 01:56:36,960

can explain to the audience what the no

3391

01:56:40,390 --> 01:56:38,719

ghost theorem is in string theory and

3392

01:56:43,270 --> 01:56:40,400

then its connection to the

3393

01:56:44,790 --> 01:56:43,280

moonshine conjecture um and you're

3394

01:56:46,149 --> 01:56:44,800

allowed to go into technical detail if

3395

01:56:47,669 --> 01:56:46,159

you feel like the audience well they're

3396

01:56:47,990 --> 01:56:47,679

gonna lose you or even me then that's

3397

01:56:49,510 --> 01:56:48,000

fine

3398

01:56:51,189 --> 01:56:49,520

this i could probably explain if you

3399

01:56:53,589 --> 01:56:51,199

gave me a semester course

3400

01:56:55,109 --> 01:56:53,599

um but here goes first of all the name

3401

01:56:58,149 --> 01:56:55,119

no ghost thing was a sort of

3402

01:56:59,510 --> 01:56:58,159

pun or word play so um in in theoretical

3403

01:57:02,629 --> 01:56:59,520

physics there are things called no

3404

01:57:03,589 --> 01:57:02,639

go theorems which mean something doesn't

3405

01:57:05,830 --> 01:57:03,599

work i mean you

3406

01:57:07,669 --> 01:57:05,840

you can't there are various no go hidden

3407

01:57:10,070 --> 01:57:07,679

variable themes the no ghost theorists

3408

01:57:13,189 --> 01:57:10,080

will sort of play on words

3409

01:57:15,189 --> 01:57:13,199

and what a ghost is

3410

01:57:18,229 --> 01:57:15,199

in string theory is a name for a

3411

01:57:20,390 --> 01:57:18,239

negative norm vector in a hilbert space

3412

01:57:21,830 --> 01:57:20,400

and this is extremely disturbing because

3413

01:57:23,589 --> 01:57:21,840

hilbert spaces aren't allowed to have

3414

01:57:24,070 --> 01:57:23,599

negative norm vectors so if you've got a

3415

01:57:25,990 --> 01:57:24,080

negative

3416

01:57:27,189 --> 01:57:26,000

norm vector that that rather messes

3417

01:57:28,950 --> 01:57:27,199

everything up

3418

01:57:30,229 --> 01:57:28,960

and so in order to get quantum mechanics

3419

01:57:32,390 --> 01:57:30,239

working you've got to make sure there

3420

01:57:34,870 --> 01:57:32,400

are no negative norm vectors in other

3421

01:57:38,310 --> 01:57:34,880

words there are no ghosts because

3422

01:57:40,790 --> 01:57:38,320

negative norm vectors are called ghosts

3423

01:57:42,709 --> 01:57:40,800

so when you take a string and try and

3424

01:57:45,589 --> 01:57:42,719

quantize it

3425

01:57:47,510 --> 01:57:45,599

you find you've got this big space and

3426

01:57:50,629 --> 01:57:47,520

sometimes it has negative normal vectors

3427

01:57:52,470 --> 01:57:50,639

in which is really tiresome

3428

01:57:54,229 --> 01:57:52,480

and the no ghost theorem proof by i

3429

01:57:56,390 --> 01:57:54,239

think it was brower and

3430

01:57:58,390 --> 01:57:56,400

goddard and thorne says that if the

3431

01:57:59,830 --> 01:57:58,400

string happens to be living in 26

3432

01:58:01,830 --> 01:57:59,840

dimensions

3433

01:58:03,589 --> 01:58:01,840

then everything is nice and you you

3434

01:58:06,390 --> 01:58:03,599

don't get any ghosts

3435

01:58:07,589 --> 01:58:06,400

and if it's in 27 dimensions you do get

3436

01:58:10,709 --> 01:58:07,599

ghosts and it's

3437

01:58:11,270 --> 01:58:10,719

really bizarre this this number 26 turns

3438

01:58:13,189 --> 01:58:11,280

up i mean

3439

01:58:15,350 --> 01:58:13,199

you you can imagine something special

3440

01:58:16,390 --> 01:58:15,360

happening in two dimensions or maybe

3441

01:58:19,589 --> 01:58:16,400

three dimensions but

3442

01:58:22,950 --> 01:58:19,599

26 dimensions is just ridiculous

3443

01:58:25,910 --> 01:58:22,960

so um that that that's why string theory

3444

01:58:27,830 --> 01:58:25,920

works in 26 dimensions is because this

3445

01:58:29,990 --> 01:58:27,840

there's no ghost theorem and then you

3446

01:58:32,310 --> 01:58:30,000

you get super string theory whether

3447

01:58:33,750 --> 01:58:32,320

where the critical dimension is 10

3448

01:58:35,910 --> 01:58:33,760

rather than 26

3449

01:58:37,350 --> 01:58:35,920

and that's still a bit tiresome because

3450

01:58:38,229 --> 01:58:37,360

we want to bring it down to four

3451
01:58:41,510 --> 01:58:38,239
dimensions

3452
01:58:43,189 --> 01:58:41,520
and there are various ways you can try

3453
01:58:44,470 --> 01:58:43,199
and get it down to four dimensions but

3454
01:58:47,030 --> 01:58:44,480
none of them seems to be totally

3455
01:58:49,830 --> 01:58:47,040
satisfactory yet

3456
01:58:51,669 --> 01:58:49,840
um and 26 dimensions is really nice

3457
01:58:52,790 --> 01:58:51,679
because it ties up with the monster and

3458
01:58:56,550 --> 01:58:52,800
the leech lattice

3459
01:58:58,550 --> 01:58:56,560
dimensions

3460
01:59:00,310 --> 01:58:58,560
and it turns out that if you've got the

3461
01:59:01,430 --> 01:59:00,320
leech lattice there's a very natural

3462
01:59:03,750 --> 01:59:01,440
construction

3463
01:59:05,109 --> 01:59:03,760

you you sort of embedded in laurentian

3464

01:59:08,149 --> 01:59:05,119
space and that involves adding

3465

01:59:11,350 --> 01:59:08,159
two to the dimension so the

3466

01:59:13,589 --> 01:59:11,360
the 26 dimensions of the no ghost theme

3467

01:59:15,510 --> 01:59:13,599
and string theory is

3468

01:59:17,669 --> 01:59:15,520
is very close related to the 24

3469

01:59:18,709 --> 01:59:17,679
dimensions that the leech lattice lives

3470

01:59:20,229 --> 01:59:18,719
in

3471

01:59:21,830 --> 01:59:20,239
and the leech lattice is connected to

3472

01:59:24,070 --> 01:59:21,840
the monster yeah so

3473

01:59:25,830 --> 01:59:24,080
so actually that's another these bizarre

3474

01:59:27,510 --> 01:59:25,840
coincidences that i mentioned that

3475

01:59:30,629 --> 01:59:27,520
always appears whenever modular

3476

01:59:34,470 --> 01:59:30,639

functions and forms turn up because the

3477

01:59:36,550 --> 01:59:34,480

the the modular forms are working

3478

01:59:38,790 --> 01:59:36,560

doing very special things in 24

3479

01:59:42,470 --> 01:59:38,800

dimensions

3480

01:59:43,910 --> 01:59:42,480

no ghosts but

3481

01:59:45,350 --> 01:59:43,920

there are other flavors of string theory

3482

01:59:46,070 --> 01:59:45,360

so do they have ghosts in other

3483

01:59:50,709 --> 01:59:46,080

dimensions

3484

01:59:52,070 --> 01:59:50,719

happens if you take the simplest

3485

01:59:54,390 --> 01:59:52,080

possible version of

3486

01:59:56,229 --> 01:59:54,400

string theory and as you say there are

3487

01:59:57,669 --> 01:59:56,239

lots of other flavors in string theorem

3488

01:59:59,669 --> 01:59:57,679

these tend to have different critical

3489

02:00:00,950 --> 01:59:59,679

dimensions so that the next simplest is

3490

02:00:03,189 --> 02:00:00,960

super strings and

3491

02:00:04,709 --> 02:00:03,199

ten dimensions and you you can sort of

3492

02:00:08,790 --> 02:00:04,719

fudge around a bit and find

3493

02:00:11,270 --> 02:00:08,800

things going on in 18 or 14 or

3494

02:00:13,109 --> 02:00:11,280

six dimensions but the the these are all

3495

02:00:16,709 --> 02:00:13,119

getting a bit more complicated

3496

02:00:18,550 --> 02:00:16,719

26 is the is the simplest case and

3497

02:00:20,550 --> 02:00:18,560

lower dimensions get more and more

3498

02:00:22,310 --> 02:00:20,560

complicated

3499

02:00:23,510 --> 02:00:22,320

are there higher dimensions than 26 or

3500

02:00:24,229 --> 02:00:23,520

is it just prove that that's the kind of

3501

02:00:27,750 --> 02:00:24,239

anyone

3502

02:00:29,430 --> 02:00:27,760

has managed for the ghosts i mean 26

3503

02:00:30,790 --> 02:00:29,440

seems to be an upper bound for all this

3504

02:00:34,390 --> 02:00:30,800

nice stuff going on

3505

02:00:35,910 --> 02:00:34,400

as far as anyone can tell okay man so

3506

02:00:38,070 --> 02:00:35,920

what's your plans

3507

02:00:40,790 --> 02:00:38,080

for next where can people find out more

3508

02:00:41,669 --> 02:00:40,800

about you where can people find a map

3509

02:00:44,070 --> 02:00:41,679

more about me

3510

02:00:47,430 --> 02:00:44,080

um if i ever find out i'll i'll close it

3511

02:00:51,430 --> 02:00:49,510

i don't know wikipedia maybe i don't

3512

02:00:52,629 --> 02:00:51,440

know your youtube page i'll link it in

3513

02:00:57,030 --> 02:00:52,639

the description

3514

02:00:59,109 --> 02:00:57,040

yeah yeah what's next for you

3515

02:01:00,790 --> 02:00:59,119

what's next to me i'm trying to get this

3516

02:01:02,629 --> 02:01:00,800

problem that i've been working on a long

3517

02:01:03,270 --> 02:01:02,639

time to see if it either works or

3518

02:01:07,430 --> 02:01:03,280

doesn't

3519

02:01:10,629 --> 02:01:07,440

and this well i hope it will be

3520

02:01:12,229 --> 02:01:10,639

sold soon but i've been in this position

3521

02:01:14,149 --> 02:01:12,239

of thinking i've solved at least a dozen

3522

02:01:15,830 --> 02:01:14,159

times in the past and every single time

3523

02:01:19,109 --> 02:01:15,840

it's failed so

3524

02:01:20,629 --> 02:01:19,119

i don't know professor thank you so much

3525

02:01:22,229 --> 02:01:20,639

this has been a pleasure

3526

02:01:25,189 --> 02:01:22,239

oh yeah well thanks for the interview

3527

02:01:26,709 --> 02:01:25,199

it's been a instructive experience

3528

02:01:29,030 --> 02:01:26,719

and i hope you're going to edit out all

3529

02:01:30,390 --> 02:01:29,040

the most embarrassing things i've said

3530

02:01:32,070 --> 02:01:30,400

um it's actually only going to be a

3531

02:01:32,470 --> 02:01:32,080

compilation of the embarrassing things

3532

02:01:34,870 --> 02:01:32,480

you've said

3533

02:01:36,070 --> 02:01:34,880

yes i should have yeah it's it's like

3534

02:01:39,109 --> 02:01:36,080

when you have a newspaper

3535

02:01:40,550 --> 02:01:39,119

interview you you say one dumb thing in