1
00:00:34,030 --> 00:00:27,880
9 we have a go for main engine start

2
00:00:37,390 --> 00:00:34,040
five four three two one zero booster

3
00:01:06,100 --> 00:00:37,400
ignition and liftoff of Columbia a new

4
00:01:12,609 --> 00:01:06,110
decade of spaceflight begins six five

5
00:01:15,310 --> 00:01:12,619
four three two one ignition and liftoff

6
00:01:21,900 --> 00:01:15,320
of discovery and the Ulysses spacecraft

7
00:01:31,240 --> 00:01:25,840
that Space Shuttle Orbiter is rocketing

8
00:01:36,910 --> 00:01:31,250
into space but what is space how do we

9
00:01:40,539 --> 00:01:36,920
get there how do we stay there how do we

10
00:01:43,210 --> 00:01:40,549
get back to earth again well before we

11
00:01:46,980 --> 00:01:43,220
answer these questions let's look at

12
00:01:50,469 --> 00:01:46,990
some history of man Rockets this man

13
00:01:53,620 --> 00:01:50,479

Robert H Goddard is considered to be the

14
00:01:57,270 --> 00:01:53,630
father of modern rocketry he began

15
00:02:00,459 --> 00:01:57,280
testing Rockets as a young man and in

16
00:02:04,300 --> 00:02:00,469
1926 he launched the world's first

17
00:02:06,700 --> 00:02:04,310
liquid-fuel rocket he was also the first

18
00:02:11,949 --> 00:02:06,710
to propose using both solid and liquid

19
00:02:16,869 --> 00:02:15,250
why is that an important idea because

20
00:02:23,259 --> 00:02:16,879
that's how he boosts the Space Shuttle

21
00:02:25,960 --> 00:02:23,269
into orbit today it was in 1956 when a

22
00:02:28,599 --> 00:02:25,970
team of scientists engineers led by

23
00:02:33,069 --> 00:02:28,609
Bernhard von Braun launched the Jupiter

24
00:02:35,110 --> 00:02:33,079
C rocket this was the first time that we

25
00:02:39,520 --> 00:02:35,120
launched anything that went high enough

26
00:02:43,240 --> 00:02:39,530
to get into space two years later

27
00:02:45,369 --> 00:02:43,250
another Jupiter C traveled in space but

28
00:02:50,140 --> 00:02:45,379
this time had left a satellite up there

29
00:02:52,119 --> 00:02:50,150
to orbit the earth then in 1961 only

30
00:02:55,330 --> 00:02:52,129
months after the Soviet Union sent their

31
00:02:57,339 --> 00:02:55,340
first astronaut into space NASA launched

32
00:03:01,599 --> 00:02:57,349
the first American into space on board

33
00:03:05,860 --> 00:03:01,609
the Freedom say things were moving

34
00:03:08,250 --> 00:03:05,870
pretty fast first we had the mercury

35
00:03:17,100 --> 00:03:15,119
then Gemini and then just eight years

36
00:03:20,580 --> 00:03:17,110
after the first human would went into

37
00:03:26,100 --> 00:03:20,590
space a Saturn 5 rocket launched the

38
00:03:29,990 --> 00:03:26,110

Apollo spacecraft carrying the first

39
00:03:39,720 --> 00:03:32,940
today astronauts fly into space in a

40
00:03:44,369 --> 00:03:39,730
different vehicle the Space Shuttle

41
00:03:46,949 --> 00:03:44,379
Orbiter to give us enough energy to get

42
00:03:50,099 --> 00:03:46,959
into orbit we use special engines and

43
00:03:57,119 --> 00:03:50,109
propellants let's look at the shuttle a

44
00:04:00,030 --> 00:03:57,129
little differently this is what we call

45
00:04:03,089 --> 00:04:00,040
the stack sitting on the launch pad here

46
00:04:10,589 --> 00:04:03,099
in Florida let's look at it the way an

47
00:04:18,659 --> 00:04:14,429
the solid rocket boosters or SRBs burn a

48
00:04:20,580 --> 00:04:18,669
solid fuel the external tank where ET

49
00:04:23,570 --> 00:04:20,590
carries liquid oxygen and liquid

50
00:04:26,400 --> 00:04:23,580
hydrogen for the shuttles main engines

51
00:04:30,689 --> 00:04:26,410
this combination of solid and liquid

52
00:04:32,700 --> 00:04:30,699
propellants are very powerful we're

53
00:04:37,650 --> 00:04:32,710
launch we start the liquid main engines

54
00:04:40,020 --> 00:04:37,660
burst then the solid rocket boosters

55
00:04:45,420 --> 00:04:40,030
ignite and lift the whole stack off the

56
00:04:47,460 --> 00:04:45,430
pad downrange twenty two nautical miles

57
00:04:49,439 --> 00:04:47,470
the solid rocket boosters push the

58
00:04:50,700 --> 00:04:49,449
shuttle for about two minutes and up

59
00:04:53,430 --> 00:04:50,710
through the thickest part of the

60
00:04:59,100 --> 00:04:53,440
atmosphere then we separate from the

61
00:05:01,770 --> 00:04:59,110
Boosters the shuttles main engines

62
00:05:02,159 --> 00:05:01,780
continue to burn for another seven

63
00:05:04,800 --> 00:05:02,169

minutes

64
00:05:24,150 --> 00:05:04,810
pushing the orbiter fast enough to get

65
00:05:30,310 --> 00:05:28,180
and here's the result we're in space but

66
00:05:33,070 --> 00:05:30,320
we're in space are we in other words how

67
00:05:37,480 --> 00:05:33,080
far above the earth have we come let's

68
00:05:41,920 --> 00:05:37,490
use this picture to help explain here is

69
00:05:43,600 --> 00:05:41,930
the surface of the earth here would be

70
00:05:46,000 --> 00:05:43,610
the Earth's highest mountain Mount

71
00:05:49,210 --> 00:05:46,010
Everest which is about 6 miles high and

72
00:05:52,330 --> 00:05:49,220
right here would be where commercial

73
00:05:55,720 --> 00:05:52,340
airplanes fly about 6 to 7 miles above

74
00:05:58,870 --> 00:05:55,730
sea level the astronauts that went to

75
00:06:00,970 --> 00:05:58,880
the moon went 240 thousand miles above

76
00:06:04,060 --> 00:06:00,980
the earth and if we can put that on this

77
00:06:07,270 --> 00:06:04,070
picture to scale it would be 5000 feet

78
00:06:09,640 --> 00:06:07,280
this way well where does that leave us

79
00:06:12,640 --> 00:06:09,650
here in the Space Shuttle well right now

80
00:06:17,110 --> 00:06:12,650
in the Space Shuttle we are about right

81
00:06:18,820 --> 00:06:17,120
here 160 miles above the earth for

82
00:06:21,940 --> 00:06:18,830
example though the Space Shuttle can

83
00:06:24,190 --> 00:06:21,950
even go higher sts-31 that deployed the

84
00:06:31,140 --> 00:06:24,200
Hubble Space Telescope went all the way

85
00:06:38,580 --> 00:06:33,720
so what's it like up here well let's do

86
00:06:39,750 --> 00:06:38,590
a weather report from space well Tom I'm

87
00:06:42,930 --> 00:06:39,760
gonna have a little problem with that

88
00:06:44,400 --> 00:06:42,940

because there is no weather in space in

89
00:06:46,620 --> 00:06:44,410
order to have whether you have to have

90
00:06:47,969 --> 00:06:46,630
an atmosphere up here in the Space

91
00:06:50,670 --> 00:06:47,979
Shuttle we're well above the Earth's

92
00:06:52,710 --> 00:06:50,680
atmosphere so I can't give you a port on

93
00:06:53,760 --> 00:06:52,720
their weather but I can tell you what

94
00:06:57,570 --> 00:06:53,770
the conditions are going to be like

95
00:06:59,250 --> 00:06:57,580
outside today we can expect a scorching

96
00:07:02,159 --> 00:06:59,260
high of about 300 degrees Fahrenheit

97
00:07:05,520 --> 00:07:02,169
outside today in the Sun that's about

98
00:07:08,210 --> 00:07:05,530
150 degrees celcius down to a real

99
00:07:10,950 --> 00:07:08,220
freezing low of 150 degrees below zero

100
00:07:13,260 --> 00:07:10,960
which is a minus 100 degrees Celsius in

101
00:07:15,510 --> 00:07:13,270
the shade we can expect the relative

102
00:07:17,969 --> 00:07:15,520
humidity to be zero and our barometric

103
00:07:19,260 --> 00:07:17,979
pressure is also going to be zero now

104
00:07:21,540 --> 00:07:19,270
some of our viewers out there may be

105
00:07:23,340 --> 00:07:21,550
wondering why are these extreme

106
00:07:25,140 --> 00:07:23,350
conditions outside when we're only a

107
00:07:26,520 --> 00:07:25,150
hundred and sixty miles up above the

108
00:07:28,800 --> 00:07:26,530
Earth's surface and the living

109
00:07:30,480 --> 00:07:28,810
conditions down there are so nice well

110
00:07:33,090 --> 00:07:30,490
the reason is is down on the surface of

111
00:07:35,820 --> 00:07:33,100
the earth we have an atmosphere the

112
00:07:38,159 --> 00:07:35,830
atmosphere performed as a protective

113
00:07:42,000 --> 00:07:38,169

blanket for us when we live down on the

114
00:07:43,379 --> 00:07:42,010
surface of the earth here for example is

115
00:07:45,750 --> 00:07:43,389
a picture of what the earth looks like

116
00:07:47,610 --> 00:07:45,760
from a satellite 23,000 miles above the

117
00:07:48,870 --> 00:07:47,620
earth you can see that much of the

118
00:07:51,570 --> 00:07:48,880
surface of the earth is covered by

119
00:07:53,279 --> 00:07:51,580
clouds these clouds are the part of the

120
00:07:55,350 --> 00:07:53,289
atmosphere that you can see the visible

121
00:07:57,450 --> 00:07:55,360
part of the atmosphere the clouds were

122
00:07:59,279 --> 00:07:57,460
made up of water molecules those water

123
00:08:01,230 --> 00:07:59,289
molecules are what account for the

124
00:08:03,420 --> 00:08:01,240
relative humidity of our atmosphere the

125
00:08:05,430 --> 00:08:03,430
total weight of the atmosphere above a

126
00:08:07,529 --> 00:08:05,440
point on the surface of the earth is

127
00:08:10,230 --> 00:08:07,539
what it makes up for the barometric

128
00:08:11,640 --> 00:08:10,240
pressure now we don't have to worry

129
00:08:12,750 --> 00:08:11,650
about our climate here in the Space

130
00:08:15,210 --> 00:08:12,760
Shuttle when we're up here in space

131
00:08:17,190 --> 00:08:15,220
because we have an air-conditioner but

132
00:08:19,650 --> 00:08:17,200
we call our environmental control system

133
00:08:22,110 --> 00:08:19,660
on board this environmental control

134
00:08:24,900 --> 00:08:22,120
system will maintain our temperature a

135
00:08:27,260 --> 00:08:24,910
nice comfortable 77 degrees Fahrenheit

136
00:08:29,460 --> 00:08:27,270
which is about 25 degrees Celsius

137
00:08:32,070 --> 00:08:29,470
relative humidity will stay at about a

138
00:08:34,370 --> 00:08:32,080

constant 50% enter barometric pressure

139
00:08:37,220 --> 00:08:34,380
will be about 29.92 inches of mercury

140
00:08:43,100 --> 00:08:37,230
back to you Tom

141
00:08:45,800 --> 00:08:43,110
thanks Bruce as you can see the

142
00:08:47,900 --> 00:08:45,810
environment in space is very harsh so

143
00:08:49,880 --> 00:08:47,910
here in the orbiter we have to make the

144
00:09:02,110 --> 00:08:49,890
environment duplicate the environment

145
00:09:07,360 --> 00:09:04,840
and even though we're over 150 miles up

146
00:09:09,819 --> 00:09:07,370
in space here the pressure inside the

147
00:09:11,799 --> 00:09:09,829
space shuttle is almost the same as it

148
00:09:16,119 --> 00:09:11,809
is at sea level see it's fool this

149
00:09:19,420 --> 00:09:16,129
altimeter into reading almost zero well

150
00:09:23,110 --> 00:09:19,430
now we know where space is and what

151
00:09:28,960 --> 00:09:23,120
space is how do we stay here

152
00:09:32,850 --> 00:09:28,970
once we've arrived well 300 years ago an

153
00:09:46,850 --> 00:09:32,860
English scientist Sir Isaac Newton

154
00:09:46,860 --> 00:09:51,610
he began by showing a very high mountain

155
00:10:00,280 --> 00:09:54,770
the imaginary mountain was so high that

156
00:10:14,519 --> 00:10:03,320
he put a cannon on top of the mountain

157
00:10:20,740 --> 00:10:18,730
okay here's our imaginary mountain let's

158
00:10:26,460 --> 00:10:20,750
pretend that we can climb to the top of

159
00:10:30,699 --> 00:10:29,170
now if we throw one of these baseballs

160
00:10:33,310 --> 00:10:30,709
straight out from the top of the

161
00:10:38,980 --> 00:10:33,320
mountain when it goes straight out like

162
00:10:46,150 --> 00:10:38,990
a ball straight down like B or fall on a

163
00:10:48,210 --> 00:10:46,160

curved path while C is correct the

164
00:10:51,100 --> 00:10:48,220
baseball would fall on a curved path

165
00:10:54,280 --> 00:10:51,110
even on this tall mountain it still

166
00:10:56,920 --> 00:10:54,290
feels gravity this is because the ball

167
00:10:59,680 --> 00:10:56,930
has two motions acting on it at the same

168
00:11:04,329 --> 00:10:59,690
time it's trying to go straight out and

169
00:11:06,519 --> 00:11:04,339
it's also falling toward the earth the

170
00:11:11,910 --> 00:11:06,529
result is the baseball travels on a

171
00:11:22,730 --> 00:11:15,119
now let's throw another ball only this

172
00:11:29,750 --> 00:11:27,800
see it goes farther than the first if we

173
00:11:35,960 --> 00:11:29,760
throw another ball even faster than the

174
00:11:39,380 --> 00:11:35,970
last one that goes farther still so the

175
00:11:43,110 --> 00:11:39,390
faster we throw the balls the farther

176
00:11:50,160 --> 00:11:45,449
now we'll take our last ball and throw

177
00:11:54,269 --> 00:11:50,170
it as hard as we can just like the other

178
00:11:56,970 --> 00:11:54,279
balls it falls in a curved path but this

179
00:12:02,840 --> 00:11:56,980
one is moving so fast that it circles

180
00:12:05,730 --> 00:12:02,850
the earth we'll have to duck to missile

181
00:12:08,400 --> 00:12:05,740
it won't be safe to stand up for a while

182
00:12:11,069 --> 00:12:08,410
because unless something gets in the way

183
00:12:15,480 --> 00:12:11,079
the ball will continue to fall around

184
00:12:19,290 --> 00:12:15,490
the earth on a curved path we call this

185
00:12:21,660 --> 00:12:19,300
an orbit of course the Space Shuttle

186
00:12:23,759 --> 00:12:21,670
doesn't launch when the mountain but we

187
00:12:35,400 --> 00:12:23,769
still need a lot of speed to get into an

188
00:12:41,069 --> 00:12:38,099

so how fast do we need to be going to

189
00:12:42,869 --> 00:12:41,079
get into orbit well it's a space shuttle

190
00:12:45,379 --> 00:12:42,879
at a speedometer like the one in your

191
00:12:48,150 --> 00:12:45,389
car it would have to get all the way to

192
00:12:49,609 --> 00:12:48,160
17,500 miles per hour to make it into

193
00:12:53,939 --> 00:12:49,619
space

194
00:12:55,769 --> 00:12:53,949
so how fast is that well it took the

195
00:13:12,300 --> 00:12:55,779
early pioneers months to cross the

196
00:13:27,390 --> 00:13:14,290
it took the first transcontinental

197
00:13:32,260 --> 00:13:29,860
it would take about three days of

198
00:13:39,130 --> 00:13:32,270
driving round the clock to get across by

199
00:13:40,450 --> 00:13:39,140
car and it takes about five hours for

200
00:13:43,210 --> 00:13:40,460
the average airline that's like

201
00:13:45,460 --> 00:13:43,220
coast-to-coast but on board the shuttle

202
00:13:49,720 --> 00:13:45,470
we cross the country in ten minutes

203
00:13:51,420 --> 00:13:49,730
that's about five miles a second you see

204
00:13:55,330 --> 00:13:51,430
the Space Shuttle goes around the earth

205
00:13:58,540 --> 00:13:55,340
16 times every earth day that means we

206
00:14:02,650 --> 00:13:58,550
see a sunrise and a sunset once every 90

207
00:14:05,080 --> 00:14:02,660
minutes this could be a problem up here

208
00:14:15,290 --> 00:14:05,090
on the orbiter if I woke up when it was

209
00:14:39,050 --> 00:14:17,420
I'd be getting up and going to sleep

210
00:14:49,689 --> 00:14:39,060
every 45 minutes so instead we just plan

211
00:14:54,199 --> 00:14:52,669
another thing you should know is we just

212
00:14:56,989 --> 00:14:54,209
don't float around on the orbiter

213
00:15:00,349 --> 00:14:56,999

because there is no gravity we still

214
00:15:05,160 --> 00:15:00,359
feel Earth's gravity so why are we

215
00:15:12,239 --> 00:15:08,819
because we're falling let's say this

216
00:15:15,449 --> 00:15:12,249
string is gravity and let's say this

217
00:15:19,789 --> 00:15:15,459
Apple is like a spaceship orbiting the

218
00:15:23,539 --> 00:15:19,799
Earth you see its gravity in our speed

219
00:15:27,030 --> 00:15:23,549
that keeps us in orbit without gravity

220
00:15:28,400 --> 00:15:27,040
we would fly off into space and never

221
00:15:31,079 --> 00:15:28,410
come back

222
00:15:36,629 --> 00:15:31,089
here's another example when I dropped

223
00:15:38,519 --> 00:15:36,639
this Apple on earth it falls when I drop

224
00:15:40,650 --> 00:15:38,529
an apple here on the Space Shuttle it

225
00:15:43,280 --> 00:15:40,660
falls - it just doesn't look like it's

226
00:15:48,910 --> 00:15:45,320
and that's because we're all falling

227
00:15:51,050 --> 00:15:48,920
together the Apple me and the orbiter

228
00:15:55,490 --> 00:15:51,060
we're not falling towards the earth

229
00:16:05,819 --> 00:15:57,500
let's imagine that we can send Bruce

230
00:16:16,290 --> 00:16:08,129
the elevator is going to the top of a

231
00:16:21,840 --> 00:16:18,870
suddenly when he reaches the top the

232
00:16:24,210 --> 00:16:21,850
cable breaks in the elevator car with

233
00:16:27,240 --> 00:16:24,220
Bruce in it begins to fall what will

234
00:16:29,520 --> 00:16:27,250
happen inside the elevator well since

235
00:16:33,030 --> 00:16:29,530
he's falling and the elevator is falling

236
00:16:34,890 --> 00:16:33,040
the same rate he starts to float his

237
00:16:36,060 --> 00:16:34,900
body isn't pushing on the inside of the

238
00:16:41,130 --> 00:16:36,070

elevator anymore

239
00:16:43,290 --> 00:16:41,140
he has no weight he's weightless if he

240
00:16:45,420 --> 00:16:43,300
had an apple with him it would float too

241
00:16:48,000 --> 00:16:45,430
just like the one in the orbiter because

242
00:16:51,240 --> 00:16:48,010
Bruce the Apple and the elevator would

243
00:16:56,030 --> 00:16:51,250
all be falling together it would be a

244
00:16:58,500 --> 00:16:56,040
fun ride until he hit the bottom and

245
00:17:01,410 --> 00:16:58,510
that's why things float around up here

246
00:17:03,150 --> 00:17:01,420
even really big things because we're all

247
00:17:06,350 --> 00:17:03,160
falling on a curved path around the

248
00:17:12,559 --> 00:17:09,239
well now our work in space is done and

249
00:17:16,949 --> 00:17:12,569
it's time to go home so how do we do it

250
00:17:20,669 --> 00:17:16,959
well first we have to slow down let's go

251
00:17:23,879 --> 00:17:20,679
back to our imaginary Mountain here's

252
00:17:27,329 --> 00:17:23,889
our baseball orbiting the earth it's

253
00:17:29,009 --> 00:17:27,339
going around every 90 minutes - we know

254
00:17:31,950 --> 00:17:29,019
the other baseball's weren't able to get

255
00:17:35,369 --> 00:17:31,960
into orbit because we didn't throw them

256
00:17:36,539 --> 00:17:35,379
fast enough now to bring the baseball

257
00:17:39,810 --> 00:17:36,549
back for more of it

258
00:17:52,010 --> 00:17:39,820
all we have to do is slow it down just a

259
00:18:00,530 --> 00:17:56,600
those were maneuvering engines firing we

260
00:18:05,870 --> 00:18:02,600
here's what it looks like from outside

261
00:18:10,100 --> 00:18:05,880
the orbiter when they fire they slow us

262
00:18:13,940 --> 00:18:10,110
down just enough to make a safe descent

263
00:18:18,169 --> 00:18:13,950

just like the baseball we've got to slow

264
00:18:21,010 --> 00:18:18,179
down to get out of little bit we glide

265
00:18:23,419 --> 00:18:21,020
back to earth under computer control

266
00:18:26,780 --> 00:18:23,429
until our altitude is about fifty

267
00:18:29,990 --> 00:18:26,790
thousand feet then the commander and

268
00:19:02,600 --> 00:18:30,000
pilot take over and land our space

269
00:19:08,520 --> 00:19:05,790
space is great but a safe touchdown sure

270
00:19:11,340 --> 00:19:08,530
feels good after traveling two million

271
00:19:18,360 --> 00:19:11,350
miles in five days it's nice to be back

272
00:19:20,730 --> 00:19:18,370
home again so now we know that it takes

273
00:19:22,950 --> 00:19:20,740
a lot of power to push the orbiter

274
00:19:27,210 --> 00:19:22,960
through the atmosphere and into

275
00:19:31,080 --> 00:19:27,220
low-earth orbit in space we have to go

276
00:19:33,540 --> 00:19:31,090
very fast to stay in space and we have

277
00:19:35,910 --> 00:19:33,550
to slow down just enough to allow

278
00:19:39,810 --> 00:19:35,920
Earth's gravity to pull us out of orbit

279
00:19:43,890 --> 00:19:39,820
when we want to return that's how we get

280
00:19:44,840 --> 00:19:43,900
into space how we stay there and how we

281
00:19:51,390 --> 00:19:44,850
get back