1
00:00:24,259 --> 00:00:21,980
ten nine eight we have a go for main

2
00:00:28,189 --> 00:00:24,269
engine start we have main engine start

3
00:00:31,760 --> 00:00:28,199
four three two one

4
00:01:48,719 --> 00:00:31,770
bill and liftoff liftoff of the space

5
00:01:48,729 --> 00:01:55,740
discover a performance nominal Roger

6
00:02:06,940 --> 00:01:59,529
how's the picture cover back Kevin great

7
00:02:10,059 --> 00:02:06,950
picture hello and welcome to the flight

8
00:02:11,800 --> 00:02:10,069
deck of discovery or 260 kilometres

9
00:02:16,119 --> 00:02:11,810
above the surface of the earth traveling

10
00:02:22,390 --> 00:02:16,129
at 8 kilometers per second if I look out

11
00:02:28,770 --> 00:02:22,400
the window I can see a light nice to you

12
00:02:34,050 --> 00:02:28,780
huh what's this

13
00:02:39,670 --> 00:02:34,060

hey macadamia nut must be lunch

14
00:02:41,229 --> 00:02:39,680
banana pudding this must be dessert one

15
00:02:51,759 --> 00:02:41,239
of the fun things about flying in space

16
00:02:55,410 --> 00:02:51,769
is that things float that's because we

17
00:02:59,229 --> 00:02:55,420
are in a freefall orbit about the earth

18
00:03:01,780 --> 00:02:59,239
the Space Shuttle Orbiter myself the nut

19
00:03:05,860 --> 00:03:01,790
and my pudding are all falling together

20
00:03:07,750 --> 00:03:05,870
we're weightless soft this can of

21
00:03:11,530 --> 00:03:07,760
pudding is weightless why did it hurt

22
00:03:14,470 --> 00:03:11,540
and hit my head the answer to this

23
00:03:17,289 --> 00:03:14,480
question requires a little research Wow

24
00:03:19,990 --> 00:03:17,299
let's imagine that I can send this nut

25
00:03:42,520 --> 00:03:20,000
and this can down to a laboratory on

26
00:03:49,070 --> 00:03:45,950
as you can see the can of pudding weighs

27
00:03:51,170 --> 00:03:49,080
100 times more than that but weight can

28
00:03:54,380 --> 00:03:51,180
be confusing because weight depends on

29
00:03:57,560 --> 00:03:54,390
where you do the weighing on the moon

30
00:04:02,390 --> 00:03:57,570
the nut and the can weigh only 1/6 of

31
00:04:06,020 --> 00:04:02,400
what they do here on earth and here in

32
00:04:09,350 --> 00:04:06,030
orbit they both weigh the same zero so

33
00:04:11,210 --> 00:04:09,360
why is that it's because weight depends

34
00:04:15,020 --> 00:04:11,220
upon the gravitational pull exerted on

35
00:04:18,050 --> 00:04:15,030
objects the earth is very big so its

36
00:04:19,820 --> 00:04:18,060
gravitational pull is very strong the

37
00:04:21,710 --> 00:04:19,830
moon is much smaller so its

38
00:04:25,970 --> 00:04:21,720

gravitational pull is weak and objects

39
00:04:28,880 --> 00:04:25,980
weigh much less here on earth were in

40
00:04:34,850 --> 00:04:28,890
freefall and that makes it seem like

41
00:04:36,230 --> 00:04:34,860
there's no gravity at all so objects

42
00:04:38,960 --> 00:04:36,240
have different weight depending upon

43
00:04:42,530 --> 00:04:38,970
where they are well then what does that

44
00:04:44,120 --> 00:04:42,540
have to do with the bump on my head the

45
00:04:46,790 --> 00:04:44,130
answer lies in the fact that even though

46
00:04:50,390 --> 00:04:46,800
the pudding can has no weight it does

47
00:04:53,210 --> 00:04:50,400
have mass mass is that not a matter that

48
00:04:56,570 --> 00:04:53,220
is packed into an object all objects in

49
00:05:00,020 --> 00:04:56,580
the universe have mass weight can change

50
00:05:02,060 --> 00:05:00,030
but not mass the mass of this nut and of

51
00:05:03,320 --> 00:05:02,070
this pudding can remains the same no

52
00:05:08,600 --> 00:05:03,330
matter where they are in the universe

53
00:05:10,640 --> 00:05:08,610
even here on the orbiter the can of

54
00:05:16,310 --> 00:05:10,650
pudding has more mass in the nut so it

55
00:05:19,130 --> 00:05:16,320
hit me with more force so why have we

56
00:05:21,890 --> 00:05:19,140
spent all this time explaining mass to

57
00:05:24,260 --> 00:05:21,900
you well it's because you have to

58
00:05:26,420 --> 00:05:24,270
understand the concept of mass in order

59
00:05:29,900 --> 00:05:26,430
to understand Sir Isaac Newton's three

60
00:05:34,040 --> 00:05:29,910
laws of motion and that is what this

61
00:05:40,080 --> 00:05:38,340
Nik was a pretty smart guy about 300

62
00:05:42,750 --> 00:05:40,090
years ago he came up with the first

63
00:05:44,990 --> 00:05:42,760

mathematical formulas to describe things

64
00:05:47,310 --> 00:05:45,000
in motion

65
00:05:49,350 --> 00:05:47,320
we couldn't have traveled up here into

66
00:05:55,320 --> 00:05:49,360
space without a good understanding of

67
00:05:58,890 --> 00:05:55,330
Newton's three laws of motion so what's

68
00:06:00,690 --> 00:05:58,900
the first law every material object

69
00:06:03,240 --> 00:06:00,700
continues in its state of rest or

70
00:06:06,330 --> 00:06:03,250
uniform motion in a straight line unless

71
00:06:11,490 --> 00:06:06,340
it is compelled to change that state by

72
00:06:15,260 --> 00:06:11,500
force is impressed upon it can we come

73
00:06:17,910 --> 00:06:15,270
up with a simpler way to say that an

74
00:06:20,430 --> 00:06:17,920
object at rest will remain at rest

75
00:06:23,730 --> 00:06:20,440
unless acted upon by an unbalanced force

76
00:06:25,890 --> 00:06:23,740
and an object in motion will remain in

77
00:06:29,340 --> 00:06:25,900
motion unless acted upon by an

78
00:06:33,140 --> 00:06:29,350
unbalanced force thanks professor aster

79
00:06:37,320 --> 00:06:33,150
that's much clearer you're welcome

80
00:06:37,980 --> 00:06:37,330
now for a demonstration here's the can

81
00:06:40,200 --> 00:06:37,990
of pudding

82
00:06:43,020 --> 00:06:40,210
it's at rest because it hasn't had any

83
00:06:46,530 --> 00:06:43,030
force applied to it so let's apply some

84
00:06:48,150 --> 00:06:46,540
force now our objects in motion and it

85
00:06:51,120 --> 00:06:48,160
will stay in motion at a constant speed

86
00:06:55,710 --> 00:06:51,130
in a straight line until it's acted on

87
00:06:58,339 --> 00:06:55,720
by an unbalanced force like a head don't

88
00:07:02,459 --> 00:06:58,349

try this at home

89
00:07:05,309 --> 00:07:02,469
now on to the second law it explains the

90
00:07:09,689 --> 00:07:05,319
relationship between course mass and

91
00:07:17,300 --> 00:07:09,699
acceleration force is a push or a pump

92
00:07:25,790 --> 00:07:19,890
acceleration is how fast an object

93
00:07:29,100 --> 00:07:25,800
changes its speed here's our can again

94
00:07:31,019 --> 00:07:29,110
we'll use this little air puffer to

95
00:07:41,269 --> 00:07:31,029
apply a gentle force to it for a short

96
00:07:49,830 --> 00:07:46,619
now we'll apply a greater force that did

97
00:07:51,990 --> 00:07:49,840
it it really accelerated that time the

98
00:07:55,850 --> 00:07:52,000
greater the force are greater the cans

99
00:07:58,679 --> 00:07:55,860
acceleration but how does mass come in

100
00:08:00,689 --> 00:07:58,689
the mass of an object affects how fast

101
00:08:04,439 --> 00:08:00,699
it will accelerate when a force is

102
00:08:07,050 --> 00:08:04,449
applied if you apply an equal amount of

103
00:08:11,059 --> 00:08:07,060
force to two objects the object with the

104
00:08:13,860 --> 00:08:11,069
most mass accelerates the least

105
00:08:16,680 --> 00:08:13,870
here are two cans of pudding tapioca and

106
00:08:19,260 --> 00:08:16,690
butterscotch if we apply the same force

107
00:08:20,999 --> 00:08:19,270
to both cans they should both accelerate

108
00:08:28,860 --> 00:08:21,009
the same and travel at the same rate of

109
00:08:36,170 --> 00:08:31,050
what happened one can seems to have

110
00:08:42,390 --> 00:08:39,930
wait here's the problem someone eats

111
00:08:45,000 --> 00:08:42,400
putting out of one of these cans without

112
00:08:48,380 --> 00:08:45,010
putting in the can the can has last

113
00:08:51,390 --> 00:08:48,390

class and thus it accelerates more

114
00:08:54,000 --> 00:08:51,400
Newton explained that force and mass are

115
00:08:57,350 --> 00:08:54,010
related to each other by acceleration a

116
00:09:01,650 --> 00:08:57,360
force is a push or a pull on the cam

117
00:09:05,070 --> 00:09:01,660
more force gives more acceleration mass

118
00:09:08,160 --> 00:09:05,080
resist acceleration if we gave the same

119
00:09:11,430 --> 00:09:08,170
push to two objects the one with less

120
00:09:14,610 --> 00:09:11,440
mass will accelerate more so here's our

121
00:09:19,170 --> 00:09:14,620
equation on top of the empty can and

122
00:09:24,630 --> 00:09:19,180
below the full force equals mass times

123
00:09:32,310 --> 00:09:24,640
acceleration so Newton wasn't wrong too

124
00:09:35,130 --> 00:09:32,320
late my pudding now what about Newton's

125
00:09:38,750 --> 00:09:35,140
third law of motion for every action

126
00:09:41,010 --> 00:09:38,760
there is an equal and opposite reaction

127
00:09:44,850 --> 00:09:41,020
well that's very easy to show up here in

128
00:09:48,450 --> 00:09:44,860
space what happens when Lacey pushes

129
00:09:51,000 --> 00:09:48,460
against Greg the force on each astronaut

130
00:09:52,790 --> 00:09:51,010
is equal and opposite so they go off in

131
00:09:56,100 --> 00:09:52,800
opposite directions at the same speed

132
00:10:00,000 --> 00:09:56,110
but once again mass plays a role in it

133
00:10:04,620 --> 00:10:00,010
all let's try that again but this time

134
00:10:06,540 --> 00:10:04,630
let's make it two against one the two

135
00:10:07,890 --> 00:10:06,550
crew members on the right have more maps

136
00:10:10,770 --> 00:10:07,900
together than our crew member on the

137
00:10:12,870 --> 00:10:10,780
left but the force is still equal when

138
00:10:15,990 --> 00:10:12,880

they push off of each other what do you

139
00:10:17,880 --> 00:10:16,000
think will happen now well you're right

140
00:10:23,430 --> 00:10:17,890
Lacey really goes sailing through the

141
00:10:25,610 --> 00:10:23,440
midday let's do that again this time in

142
00:10:28,320 --> 00:10:25,620
slow motion

143
00:10:30,930 --> 00:10:28,330
Lacey has less mass than the other two

144
00:10:32,520 --> 00:10:30,940
crew members Don and Greg and therefore

145
00:10:36,810 --> 00:10:32,530
he has a greater acceleration and

146
00:10:40,470 --> 00:10:36,820
travels faster let's run through these

147
00:10:41,630 --> 00:10:40,480
three laws of motion again an object at

148
00:10:44,000 --> 00:10:41,640
rest remain

149
00:10:46,400 --> 00:10:44,010
at rest unless acted upon by an

150
00:10:48,920 --> 00:10:46,410
unbalanced force and an object in motion

151
00:10:51,290 --> 00:10:48,930
will remain in motion at the same speed

152
00:10:54,020 --> 00:10:51,300
in the same direction unless acted upon

153
00:10:56,720 --> 00:10:54,030
by an unbalanced force the acceleration

154
00:11:01,540 --> 00:10:56,730
of an object depends upon its mass and

155
00:11:09,140 --> 00:11:04,010
for every action there is an equal and

156
00:11:11,990 --> 00:11:09,150
opposite reaction Newton's three laws of

157
00:11:14,060 --> 00:11:12,000
motion are not just formulas or words on