



1
00:00:10,080 --> 00:00:20,150
congratulations

2
00:00:25,910 --> 00:00:23,590
i got a question here from brian watt

3
00:00:27,509 --> 00:00:25,920
from phoenix arizona says

4
00:00:29,750 --> 00:00:27,519
greg why does the space station have to

5
00:00:32,870 --> 00:00:29,760
be in a specific orientation in order to

6
00:00:35,350 --> 00:00:32,880
dock the shuttle or resupply spacecrafts

7
00:00:37,510 --> 00:00:35,360
this is a really good question and not

8
00:00:40,549 --> 00:00:37,520
easy to explain uh quickly but i'll

9
00:00:43,270 --> 00:00:40,559
generally do my best

10
00:00:45,110 --> 00:00:43,280
basically what's happening is you know

11
00:00:46,549 --> 00:00:45,120
the orbital mechanics that's going on

12
00:00:49,350 --> 00:00:46,559
when you fire thrusters with a

13
00:00:50,790 --> 00:00:49,360

spacecraft uh have kind of a strange

14

00:00:52,470 --> 00:00:50,800

effect when you look at what the what

15

00:00:54,549 --> 00:00:52,480

the motion is between two spacecraft

16

00:00:56,470 --> 00:00:54,559

that are near each other so for example

17

00:00:59,349 --> 00:00:56,480

if if two spacecraft are right behind

18

00:01:01,349 --> 00:00:59,359

each other in in the same orbit

19

00:01:02,630 --> 00:01:01,359

and the one behind fires thrusters to

20

00:01:04,229 --> 00:01:02,640

move forward

21

00:01:06,950 --> 00:01:04,239

what's going to happen really is it's

22

00:01:08,789 --> 00:01:06,960

that spacecraft's changing its orbit and

23

00:01:10,710 --> 00:01:08,799

the new orbit

24

00:01:12,950 --> 00:01:10,720

is going to be an

25

00:01:14,710 --> 00:01:12,960

ellipse with a higher apogee the

26
00:01:17,190 --> 00:01:14,720
furthest point away halfway around the

27
00:01:19,030 --> 00:01:17,200
orbit uh from the time of the the

28
00:01:20,710 --> 00:01:19,040
thruster firing the orbit is going to be

29
00:01:21,590 --> 00:01:20,720
a little bit higher

30
00:01:23,670 --> 00:01:21,600
and

31
00:01:25,590 --> 00:01:23,680
so what's going to happen is

32
00:01:26,390 --> 00:01:25,600
45 minutes later basically at this

33
00:01:27,830 --> 00:01:26,400
altitude

34
00:01:29,990 --> 00:01:27,840
what's going to happen is that

35
00:01:31,749 --> 00:01:30,000
spacecraft would move up rather than

36
00:01:33,190 --> 00:01:31,759
forward towards the spacecraft it's

37
00:01:34,710 --> 00:01:33,200
trying to catch up with

38
00:01:36,230 --> 00:01:34,720

and also since that orbit now is a

39

00:01:37,910 --> 00:01:36,240

little bit bigger

40

00:01:40,310 --> 00:01:37,920

it takes longer to go around and

41

00:01:42,469 --> 00:01:40,320

actually it'll fall behind so thrusting

42

00:01:44,469 --> 00:01:42,479

forward results in

43

00:01:46,469 --> 00:01:44,479

floating up and falling behind which is

44

00:01:48,469 --> 00:01:46,479

very counter-intuitive and a lot of the

45

00:01:50,389 --> 00:01:48,479

orbital mechanic

46

00:01:51,910 --> 00:01:50,399

effects are kind of like that now those

47

00:01:53,350 --> 00:01:51,920

are things that happen in the plane of

48

00:01:55,429 --> 00:01:53,360

the orbit but out of the plane it's

49

00:01:57,109 --> 00:01:55,439

something completely different if you if

50

00:02:00,469 --> 00:01:57,119

you fire a thruster to move the

51
00:02:03,030 --> 00:02:00,479
spacecraft out of the plane of the orbit

52
00:02:04,630 --> 00:02:03,040
what happens is it kind of creates an

53
00:02:05,990 --> 00:02:04,640
angle between

54
00:02:08,630 --> 00:02:06,000
the two orbits one of the first

55
00:02:10,070 --> 00:02:08,640
spacecraft one of the other and you know

56
00:02:12,229 --> 00:02:10,080
two orbits that are at an angle with

57
00:02:14,470 --> 00:02:12,239
each other they cross each other twice

58
00:02:15,830 --> 00:02:14,480
uh one you know per orbit

59
00:02:17,430 --> 00:02:15,840
so what actually would happen is the

60
00:02:19,750 --> 00:02:17,440
spacecraft would move out of the orbit

61
00:02:21,589 --> 00:02:19,760
to the side and then half an orbit later

62
00:02:22,949 --> 00:02:21,599
come back and cross over again go to the

63
00:02:25,589 --> 00:02:22,959

other side and then half an hour but

64

00:02:27,270 --> 00:02:25,599

later come back and across again so

65

00:02:28,710 --> 00:02:27,280

these are kind of weird things to take

66

00:02:30,390 --> 00:02:28,720

into account when you're trying to

67

00:02:33,110 --> 00:02:30,400

manually fly a rendezvous or you can

68

00:02:35,270 --> 00:02:33,120

automatically fly around

69

00:02:37,589 --> 00:02:35,280

the in-plane motions in the auto plane

70

00:02:39,750 --> 00:02:37,599

are are different from you different

71

00:02:42,070 --> 00:02:39,760

effects from each other

72

00:02:43,350 --> 00:02:42,080

but there's a couple of places in

73

00:02:44,869 --> 00:02:43,360

that you can be relative to other

74

00:02:47,190 --> 00:02:44,879

spacecraft where you can stay for a

75

00:02:48,869 --> 00:02:47,200

while and have it not cost you fuel for

76

00:02:50,070 --> 00:02:48,879

example if you if you're below another

77

00:02:51,509 --> 00:02:50,080

spacecraft and you're trying to

78

00:02:53,509 --> 00:02:51,519

rendezvous with it but you want to stay

79

00:02:55,190 --> 00:02:53,519

there for a while if you're below in

80

00:02:56,550 --> 00:02:55,200

other words closer to the earth

81

00:02:57,910 --> 00:02:56,560

you're in a different orbit you're at a

82

00:03:00,390 --> 00:02:57,920

different altitude you're in a different

83

00:03:01,910 --> 00:03:00,400

orbit and that orbit you know takes

84

00:03:04,630 --> 00:03:01,920

different amount of time to go around

85

00:03:07,110 --> 00:03:04,640

and and um and you have to apply

86

00:03:08,710 --> 00:03:07,120

constant uh thruster firings not

87

00:03:10,869 --> 00:03:08,720

constant but you have to keep firing

88

00:03:13,110 --> 00:03:10,879

thrusters and keep yourself there so

89

00:03:15,350 --> 00:03:13,120

that costs you energy

90

00:03:17,030 --> 00:03:15,360

one place for sure you can stay relative

91

00:03:19,270 --> 00:03:17,040

to another spacecraft and not have it

92

00:03:20,869 --> 00:03:19,280

cost you any energy to stay there is

93

00:03:22,949 --> 00:03:20,879

right in front or right behind in

94

00:03:25,430 --> 00:03:22,959

exactly the same orbit

95

00:03:26,949 --> 00:03:25,440

and so these are really good places to

96

00:03:29,830 --> 00:03:26,959

approach from

97

00:03:32,789 --> 00:03:31,509

if something goes wrong when the shuttle

98

00:03:34,070 --> 00:03:32,799

approaches if something goes wrong or

99

00:03:35,750 --> 00:03:34,080

you want to check that everything is

100

00:03:37,670 --> 00:03:35,760

right right before you you know finally

101
00:03:39,509 --> 00:03:37,680
do your final maneuver to come in you

102
00:03:41,430 --> 00:03:39,519
can have time to stay in that place for

103
00:03:43,910 --> 00:03:41,440
a while and not have it cost you a lot

104
00:03:46,309 --> 00:03:43,920
of fuel to stay there so that's one of

105
00:03:48,070 --> 00:03:46,319
the main reasons the shuttle approaches

106
00:03:50,550 --> 00:03:48,080
from that side theoretically you could

107
00:03:52,789 --> 00:03:50,560
approach from any angle

108
00:03:54,630 --> 00:03:52,799
and for other reasons it's helpful you

109
00:03:56,229 --> 00:03:54,640
know if you can stay in the plane in the

110
00:03:58,830 --> 00:03:56,239
orbit plane

111
00:04:01,110 --> 00:03:58,840
you minimize you know coupling between

112
00:04:03,990 --> 00:04:01,120
axes other factors have to do with

113
00:04:05,589 --> 00:04:04,000

firing thrusters that might impact

114

00:04:07,429 --> 00:04:05,599

parts of the spacecraft you know for the

115

00:04:09,830 --> 00:04:07,439

space station with solar rays we don't

116

00:04:12,630 --> 00:04:09,840

want to impact the arrays with um with

117

00:04:14,869 --> 00:04:12,640

uh the thrust exhaust from the plumes

118

00:04:16,229 --> 00:04:14,879

from the thrusters so a lot of things

119

00:04:18,710 --> 00:04:16,239

combined but

120

00:04:20,710 --> 00:04:18,720

essentially it helps to keep things in