**The Moon Script**

Hi. Good morning everybody. How are you? I’ve got a bit of a cold so I’m going to try and make this quite a short talk I think. As usual, don't forget if you go to my site, stevenaskew.com, you can find the script for this talk and all my others and you can find listening questions and sample answers and things like that. And, if you want to hear more of these talks, please subscribe.

OK. Today we're going to talk about the moon. What is a moon? Well, a moon is basically any celestial body that orbits another celestial body. So, in our solar system alone we have 168 moons. Jupiter has 64, which is a lot. Earth, of course, only has one. Now, we say “the” moon when we refer to our moon. We say a moon when we refer to any of the other moons. OK?

Now our moon, the moon, is 4.6 billion years old. About. Give or take a day or two. It orbits our Earth in 27.3 days. It's not exactly a month. It's a little bit under a month. And it doesn't orbit in a complete circle, it has a slightly elliptical circle. That means it doesn't go completely round, it goes ever so slightly farther away ever so slightly closer back towards us. It's approximately 385,000km away. As I say, it gets a little bit further away and a little bit closer, but, on average it's about 385,000km. It has variable temperatures. On one side, in the sun, it's 123℃. A pretty hot summer's day. Ha ha ha ha. On the other side, where it doesn't get any sun, it's -233℃. That's a little bit cold. Now, the moon, of course, doesn’t … it rotates but it rotates in sync with our earth, so as our earth spins around, the moon spins around with us. Now, of course, we have phases of the moon. We have a new moon which is a moon that's just become visible, to a full moon and then no moon at all. Now, what causes these phases? Some people think it's caused by the shadow of the earth falling between the sun and the moon. So, you'd have the sun, the moon, the shadow of the earth falls on the moon and means we can’t see part of it. But, that's not actually what happens. The sun shines on one side of the moon. OK. Let's say this side with the face. This is the sun. I don't have three hands. I'm going to have to put the sun down, I'm afraid. Just imagine the sun is over here. OK. Now, this is the earth. Now, as the moon rotates around the Earth, it's like this. It doesn't turn. So, the side with the sunlight is always pointing towards the sun. But, as it … as it goes round our Earth, from over here we can see the whole face of the moon because it's reflecting all of the sunlight but as the moon goes round it's still reflecting the same amount of sunlight but the side we can see becomes smaller and smaller and smaller and smaller and smaller until, when it's over here, we can’t actually see the moon because the side that's reflecting the sunlight is between us and the sun. OK? So, rather than our shadow falling on the moon, it's just because the side that reflects the sunlight is away from us, so we can’t actually see it. Now, these are called the near side of the moon, the side we can see, and the far side of the moon, the side we can't see. This is sometimes called the dark side of the moon because, well, it's dark of course.

Ok. So, how did the moon form? There are a number of theories about this. A number of theories. I'm going to take the most popular theory at the moment, which is that very early in its creation the proto earth was still a ball of lava. It was …it had a solidified core and a slightly solidified outer skin, but it was still pretty soft. Now, another planet about the size of Mars at that time sailed across and actually impacted our earth. It hit our earth. And, of course, what happens when that happens, both planets …boof … completely squish themselves. They break up into pieces and the second planet ejects a huge amount of debris into the atmosphere. Most of the planet combines with the earth and these roll together and they form one planet. So, the earth became bigger. However, the part, the debris that was ejected into the atmosphere … ejected into the stratosphere, that spins round and over millions and millions of years it slowly clumps together and once it clumps together it develops its own gravity, it starts spinning and it attracts more and more pieces and it basically goes round outside the earth like a huge vacuum cleaner sucking up all these pieces until gradually it spins and spins and spins and becomes the moon we know today. So, it's collected all the pieces of this second planet.

Now, without the moon there is a very strong chance that I wouldn't be standing here talking to you. Why? Because I wouldn't have a topic? No. That's not true. Because the moon protects us. If you look at the surface of the moon, it's pockmarked, it's covered in holes and craters and crevices and mountains and it's smashed to pieces. Why is that? That’s because a large amount of meteors hit the moon. Now, if we didn't have a moon these meteors would fly straight through and they would hit the earth. So, the moon spins around outside our earth like a bodyguard protecting us from all these meteors that are coming in from the outer solar system. So, without the moon the earth would probably have been hit quite often and we might not be here. In fact, more than the moon, Jupiter is the biggest savior, the biggest bodyguard for us, but that's another topic.

OK. So, because the moon spins around our earth, we also have tides. High tide and low tide. Tide is when the sea level, the water level … well, the sea level rises and falls. Now, we have two tides a day. Why do we have two tides a day? Well, it's pretty easy to understand, I think. The moon has a gravity, of course. The Earth's gravity is stronger than the moon's gravity, but the moon does still have a gravity of its own and the moon attracts the earth towards it. Now, I know the earth is hard, me standing here it's pretty hard, but it still has a movable surface and as the moon moves around, it attracts part of the earth and it pulls the earth up like this. So, up here you have a high tide because the water and the earth is pulled towards the moon. \*cough\* Sorry. But, of course you have a tide on the other side as well because as the earth is pulled towards the moon it becomes elliptical. It becomes almost like an egg shape. It stretches, and it stretches as it narrows in the middle, it stretches on the poles, well, on the sides. And so, you get tides at these sites. OK? So, as the moon goes round it pulls, it pulls, it pulls, and the tides move around the Earth. So, you get two tides a day.

All right. So, we have been to the moon. Well, I never have of course, but so far twelve people have walked on the moon. The very first person to walk on the moon of course was Neil Armstrong, of course, July 21st, 1969. He flew up there on the Apollo eleven. The Apollo eleven was … well, the eleventh in a series of rockets I suppose. And that mission, that actually cost $170 billion of today's money. Could you imagine Donald Trump or anybody allowing that much money to be spent on a program at the moment? Well, maybe we'll go to Mars one day, who knows? But, I think if we do it will be the private sector, it won't be governments anymore. So, $170 billion. Now, Neil Armstrong was the first man to step on the moon. As he stepped out of the lander he said of course, those famous words: “A small step for a man, a giant leap for mankind.” Well, he says it much better than me. Hang on. I'll show you here. Yeah? Very very famous words. And since him twelve people have walked on the moon and nobody has been back since the 1970s. Why? Well, because it's basically too expensive and people cannot see a reason to go there. But, maybe one day, we will have bases up there. Maybe we'll have hotels up there. But, as I said, that would probably be the private sector that does that, private industry. I don't think governments have the ability to spend that much money on space exploration anymore when they have so many troubles, so many problems in their own countries. Education and health is obviously more important than space exploration. To your average voter.

OK. So, gravity on the moon is 17% of earth. If you watch people walking on the moon they … they bounce, they jump. Watch this one. You see how he's bouncing? You see how he's bouncing along here? That space suit he's wearing actually weighs 220kg. 220kg, but he's jumping along as though it's nothing. Gravity on the moon is 17% that of earth. Now, Americans and Russians have all been to the moon. There is American … there are American flags, there are Russian flags there. You can actually look up with satellites … not satellites sorry … you can look up with telescopes and you can see the stuff that's been left on the moon. The moon conspiracy landing, I'm not going to talk about that. It's not even worth thinking about. If you're interested, put something in the comments below and I'll talk about it at a later date, but it's just nonsense. So, you can see the things that were still left on the moon. But, who owns the moon? Well, in 1969, there was a treaty signed called the Outer Space Treaty, which basically says that no one country can own any body in space. By body, I mean planet of course, not body. So, the moon doesn't belong to anybody. And as we explore the galaxy, as we explore the universe, the solar system, hopefully this treaty will be kept, and hopefully countries won't lay claim to different parts of the solar system.

All right. So, I've nearly finished. I'm getting a bit sick. The moon is moving away from the earth at about the speed of 4cm a year. Why is that? Well, because as it's spinning around of course, basically what gravity does is, this is falling away but as it falls it gets caught in the earth’s gravity and it slowly moves around. But, of course, the moon is also being pulled by the sun's gravity which is over here. Should use the yellow ball for the sun. The sun's gravity is also pulling the moon away. So, the moon's rotation and the earth's rotation are both gradually slowing down. I mean, if you think about it, if you put a spinning top on a desk and spin it, it slowly slows down. Why? Because of friction with the desk, because of air friction. Of course, in space, there is much reduced friction, but there isn't actually no friction. There are still atoms in a square meter of space. Obviously, not as many as there are on Earth, but there are still some. And there’s cosmic rays, and there are many things. There’s dark matter, many things that can slow down a planets rotation. So, the moon and the earth are slowly spinning … sorry … the moon and the earth are slowly slowing down. So, the moon is slowly going to retreat from us. It will retreat until it reaches a point where it takes about 47 days for the moon to go around the earth. It will be that far away, and of course in the sky it would be very very small. I mean, you’ll still be able to see it, but it would be a fraction of the size it is today. Now, of course, if the moon slows down, the earth’s rotation is also going to slow down, because they make each other spin faster. So, if the earth’s rotation slows down it's going to take the earth about 47 days to make one rotation. So, a day would be 47 days. You would have 23 days of light, 23 days of dark, approximately. I couldn’t imagine that. But, that's not really something we have to worry about because that is billions of years into the future and at that point the sun will have gone red … become a red giant That means the sun will have used up all of its natural fuel and expanded to the point where it's almost reaching the earth. Another problem of course, when the earth’s … sorry … when the moon's orbit slows down, as it spins it has centrifugal force, once that stops it's going to start getting attracted in towards the earth, and its orbit right now, which is 385,000km will slowly fall. And the moon will get closer and closer and closer until it gets to within 9,492km of the Earth. Why that number? Because that number is the Roche limit for the earth. The Roche limit is the point where a celestial body gets torn apart because the second celestial body’s tidal forces are much stronger than the smaller body’s gravitational self-attraction. That means the moon has its own gravity of course. If I stand on the moon I get pulled down towards the moon. But, the earth also has another gravity and the gravity from the earth is pulling at the moon of course. And right now, the moon's gravity itself is stronger than that attraction to the earth, but once the moon gets within the Roche limit, the attraction from the earth is going to be higher than the moon's gravity itself. And, once that happens, the moon is going to get torn apart, and we're going to have a ring. The earth will have a ring like Saturn. But not for very long, because at that point the sun will have expanded probably beyond the Earth, and we won't be here. We might be on another planet somewhere. We might be another civilization. Who knows? Anyway, that's a talk for another day.

Well thank you for listening. I'm sorry I've got a bit of a cold. If you have anythings you want to … if you have any ideas you'd like me to talk about, put them in the comments below. If you liked this, click the like button, somewhere down there. If you want to subscribe, click the subscribe button, somewhere over here … over here, and I'll keep making these videos. Anyway, thanks for watching. Bye. See you next time.

**The Moon Questions**

1. Which of these is a moon?

A: A satellite orbiting a planet.

B: A meteor flying near a planet.

C: A large body orbiting a planet.

D: A planet that impacts another planet.

2. Which of these would be a good name for the theory of the moon creation that Steven explains.

A: Debris collection theory

B: Space vacuum theory

C: Meteor collision theory

D: Large planet impact theory

3. How does the moon protect us?

A: It blocks many meteors that would otherwise hit Earth.

B: It gives us tides which help us to fish.

C: It has a gravity which means Earth doesn’t spin too fast.

D: It takes a little under a month to orbit Earth once.

4. Steven says, “In fact, more than the moon, Jupiter is the biggest **savior**, the biggest bodyguard for us, but that's another topic.” Which of these words is closest in meaning to **savior**?

A: protector

B: benefactor

C: tormentor

D: contributor

5. How much did the Apollo 11 mission cost in today’s money?

A: $170,000

B: $170,000,000

C: $170,000,000,000

D: $170,000,000,000,000

6. Why does Steven think future moon exploration will be carried out by the private sector?

A: Because many people want to buy the moon

B: Because governments can’t spend that much money

C: Because space is not controlled by any one government

D: Because governments want to invest in space travel

7. What percentage of Earth’s gravity is the moon’s?

A: 7%

B: 17%

C: 70%

D: 71%

8. What is the point of the Outer Space Treaty?

A: It is to stop countries trying to own part of space.

B: It is to allocate different parts of the moon for different countries.

C: It says that the first person to land on a planet, owns it.

D: It wants to decide which country has to pay for space exploration.

9. What is the Roche limit of Earth?

A: 9,492

B: 9,942

C: 4,992

D: 2,949

10. What will happen to the moon when it falls inside Earth’s Roche limit?

A: It will fly away into space and eventually fall into the sun.

B: It will move up and down forever.

C: It will slowly stop spinning and move further away from Earth.

D: It will be torn to pieces and make a ring around Earth.

11. Do you think there will be tourist hotels on the moon one day?

12. Countries should be allowed to lay claim to the moon. Do you agree or disagree? State your reasons.

13. Explain what the Roche limit is in your own words.

14. Do you think mankind will ever colonize another planet?

15. Was it worth the price it cost to put a man on the moon?

**The Moon Answers**

1. C 2. D 3. A 4. A 5. C 6. B 7. B 8. A 9. A 10. D

11. Do you think there will be tourist hotels on the moon one day? Explain your reasons.

Yes, I do, but not for a long time. Currently, a number of companies are offering trips into space. One company takes you up to the edge of space, for a few minutes, and then back down. Another Russian company offered time on the International Space Station. The first type, a few minutes, cost $200,000. The second type, time on the ISS, cost about $40 million. At these prices there will not be many people that can afford to travel.

For tourism to the moon to be a viable concept, several problems have to be solved. Firstly, cost. This is the most obvious stepping stone. NASA rockets are non-reusable. To put 1kg of material in space costs $20,000 and to put 1kg on the moon costs $1.8 million. To bring this cost down more efficient, reusable rockets, and better fuels need to be designed. Secondly, safety. To get a person to the moon is far more dangerous than taking a cruise ship to Hawaii. And if there is an accident, there is no help on hand. Before regular tourists can set foot on the moon, completely safe, foolproof life support stations must be constructed and tested.

People will go to the moon again, and there will be hotels on the moon, but not in my lifetime. The technological problems will be overcome, and there will be enough demand to make it profitable, but it will take a long time. In the meantime, at least while I am alive, some rich space tourists will land on the moon. That is inevitable.

12. Countries should be allowed to lay claim to the moon. Do you agree or disagree? State your reasons.

 I disagree, but I can see that it will become increasingly difficult to enforce. If you look at the damage that the colonial powers have done to the world, you can see that it is very important to keep all of space neutral. No country should ever be allowed to claim any of it.

 However, space exploration is going to be increasingly carried out by private individuals and corporations and these companies are not bound by the treaty because it solely applies to countries. Many organizations will exist to place satellites or tourists in orbit, but many other organizations will exist to mine the resources that float through the solar system on comets, meteors, asteroids, the planets and their moons. How can we prevent them? Once Earth’s resources have been used up, we are going to be forced to look to the heavens, and space mining corporations will arise. We will need the resources, so we will look the other way as they ravage the solar system. They will start with the moon, possibly make a launching base there, and then move on out. It is inevitable.

13. Explain what the Roche limit is in your own words.

 The Roche limit is the distance from a planet where its gravitational attraction becomes stronger than any orbiting moon, asteroid, or other body’s own gravity. Our moon is a good example. The moon is round because its gravity is strongest at the center and pulls all of the moon’s material in towards the center. As the moon gets closer to Earth, Earth’s gravity pulls at the moon more and more. When it crosses the Roche limit, the Earth’s pull on the moon is stronger than the moon’s own gravity which is keeping it together. Once this happens it gets ripped apart. The Roche limit changes depending on the size of the planet, its mass and the size of the body orbiting it.

14. Do you think mankind will ever colonize another planet? Explain your reasons.

 I do think we will. I have two reasons for this. The first reason is a very positive one and the second reason is a very negative one. I’ll begin with the positive.

 Humans are an incredibly curious species. We always want to learn secrets, find out how things work and visit places we have never been to. Explorers have existed since the very beginning of our civilizations. It has taken us a long time, but we have explored almost all of our land based planet. We still haven’t explored the bottom of the sea in any detail, but we will. And now we have explored our planet, it is only natural that we look outwards. It took many technological developments, like the marine chronometer, for us to explore our planet, and it will take many developments for us to explore space, but necessity is the mother of invention and we will overcome all of the difficulties. And, once we have travelled far enough away from the earth, it will not make sense to keep returning, so, outposts will have to be constructed. And once you have an outpost, a town will grow up around it. And once you have towns, you will get cities. It is inevitable.

The second, more negative, reason, is that we will have to. We are approaching, or may have already passed, the tipping point for climate change. We are potentially making a planet we will not be able to live on for much longer. If that comes to pass, then we will have no choice but to find somewhere else to live.

Both of these reasons are possible. The potential outcome is the same. The only difference is that in the first case, the pioneers that want to leave will go, whereas, in the second case, everybody will want to go, but only some people will be able to.

When we have colonized other planets, it will raise interesting questions about the future of countries on Earth. Will it still be America and China, or will it be Earth I people and Earth II people?

We will travel to other worlds, and we will build outposts on them. The reason why we go is still open for discussion.

15. Was it worth the price it cost to put a man on the moon?

I would say it most definitely was, but I can understand why some people would disagree. I would like to talk about the reasons why it was worth it and then cover a couple of reasons for the opposite argument.

It was worth it because of what we learned, not just about the moon, but about us as a species. We learned that we can push ourselves and we can reach goals that seem to be impossible. We learned that we can overcome any technological difficulty we have. We learned that, if the money is available, we can invent anything. We learned that we can come together, admittedly as a country, and rise to a challenge.

Scientifically we learned a lot about the creation of the moon. We learned a lot about its geology and its geography. We answered many questions that had been speculation for thousands of years. We learned that there is no life on the moon. If we had never visited the moon, we would not know any of this.

And, to me, the most important consequence of putting a man on the man, was that we were successful. If we could reach the moon, then we can potentially reach other planets. It was the first step to exploring the solar system and maybe even the galaxy. As with anything, the first step is always the most difficult and the most important.

I can see two obvious arguments about why we shouldn’t have gone. The first, of course, is the sheer cost. $170 billion is a huge amount of money. Think how many schools or hospitals you could fund with that much money. However, I see that as an incorrect assumption. If America hadn’t put a man on the moon, it doesn’t necessarily mean that the money would have been allocated to other worthwhile courses.

And the second reason why we shouldn’t have put a man on the moon, is because the main reason America worked so hard and spent so much money was to be there before Russia. if Russia hadn’t sworn to put a man on the moon, I don’t think America would have, and we would probably still be sitting here wondering if it is made of cheese.

While I can see the arguments that suggest it was not worth the cost, I disagree. Everything we learned and the confidence it gave us a species were worth every cent.