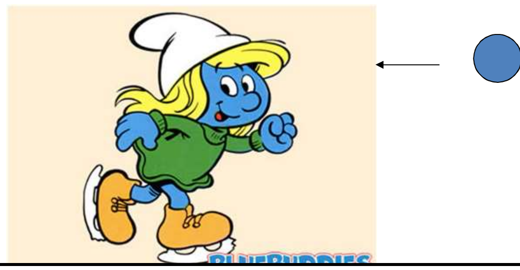
Initially: 30 kg 0 m/sec 0.5 kg 15 m/sec



What is the final velocity of Smurfette after she catches the ball?

Solution

Momentum = mass × velocity

$(\text{Total momentum})_{before} = (\text{Total momentum})_{after}$

Define left to be negative and right to be positive.

Before collision: Total Momentum = (30kg*0m/s) – (0.5kg*15m/s)

After collision: Total Momentum = - (30kg +0.5kg) * v

(velocity of Smurf and ball is the same after the catch.)

(30kg*0m/s) – (0.5kg*15m/s) = - 30.5kg *v

Solving for v ➔ v= 0.25 m/s to the left

Clicker Question

Ice hockey player A (mass 100 kg), traveling at 4 m/s on the ice, crashes into player B (mass 100 kg), who is at rest. After the collision, they are stuck together, wrestling each other. What is their speed after the collision, in m/s?

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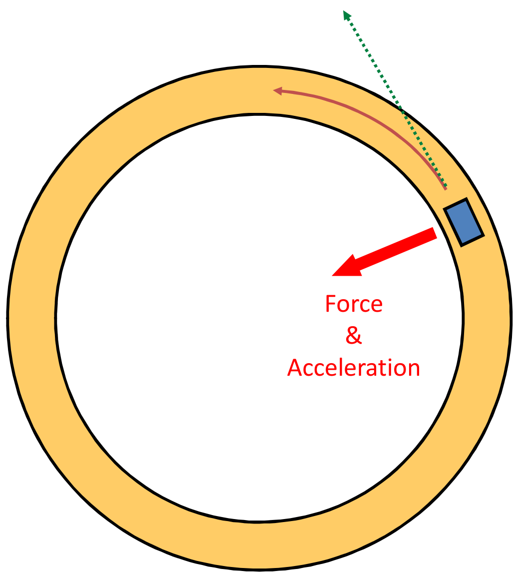
$$P_{initial} = P_{final}$$

$$m_A v_A + m_B v_B = (m_A + m_B) V$$

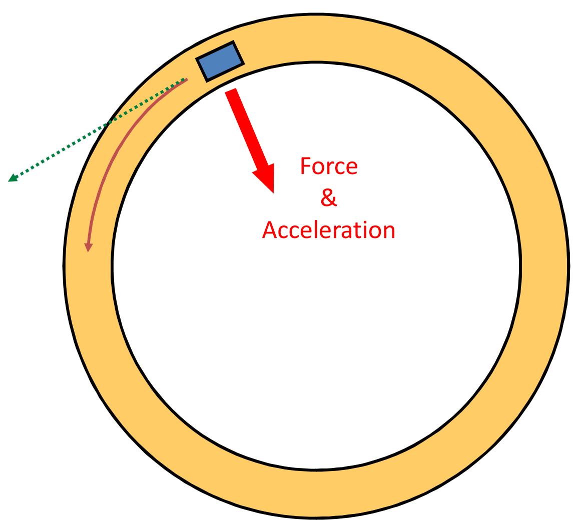
$$100\ kg\ 4\ \frac{m}{s} + 0 = 200\ kg \cdot V$$

$$V = \frac{100}{200}\ 4\ \frac{m}{s} = \underline{\underline{2\ \frac{m}{s}}}$$

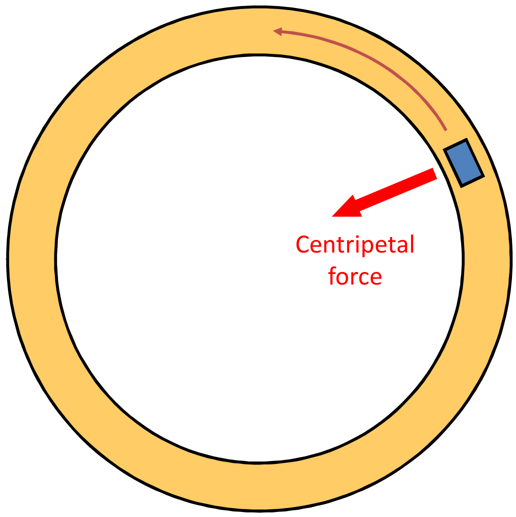
Circular motion



Circular motion



Circular motion



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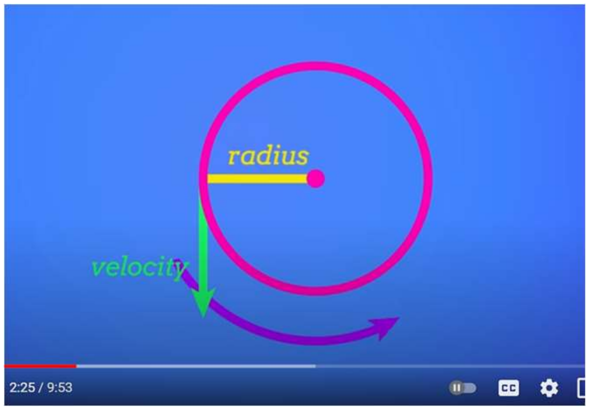
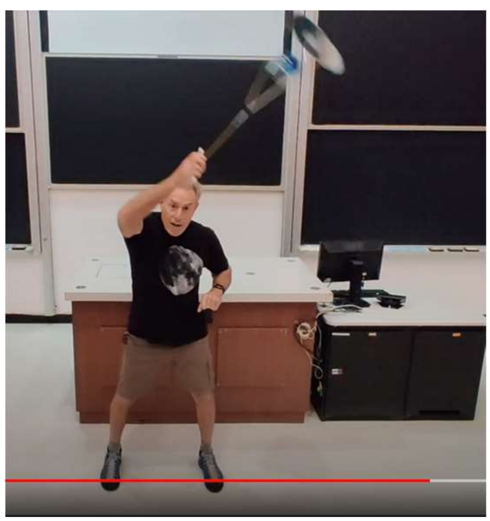
Uniform Circular Motion Video



"Greek waiter's tray" demo



Clicker Question

A car drives around a circle with a 10 m radius in 10 seconds, maintaining a constant speed. What is the car's approximate speed, in m/s?

A. 1 m/s
B. 10 m/s
C. 3.14 m/s
D. 6.28 m/s

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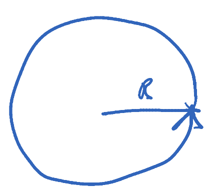
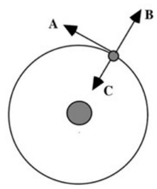


circumference $= 2\pi R$

$$\text{speed} = \frac{2\pi R}{T} = 2\pi \frac{10\,m}{10\,s} = 2\pi \frac{m}{s}$$

$\pi \approx 3.14$

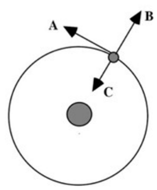
Clicker Question



The diagram shows the moon orbiting around Earth. (The direction of the moon's motion is counter-clockwise.) Is any net force exerted on the moon?

A. Yes, the net force is in the direction of arrow A.
B. Yes, the net force is in the direction of arrow B.
C. Yes, the net force is in the direction of arrow C.
D. No, because no force is needed to keep an object moving at constant speed.
E. No, because the forces cancel out.

Clicker Question



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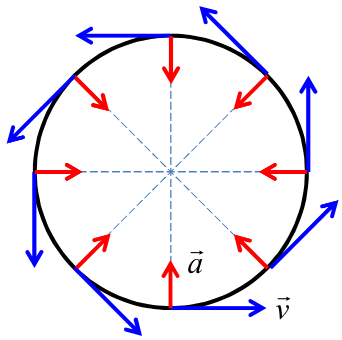
Uniform Circular Motion



$$a_{rad} = \frac{v^2}{R}$$

Clicker Question

When an object is moving on a circular path,

A. a centrifugal force accelerates the object inward.
B. a centrifugal force accelerates the object outward.
C. a centripetal force accelerates the object outward.
D. a centripetal force accelerates the object inward.
E. there is no force as long as the object's speed does not change.

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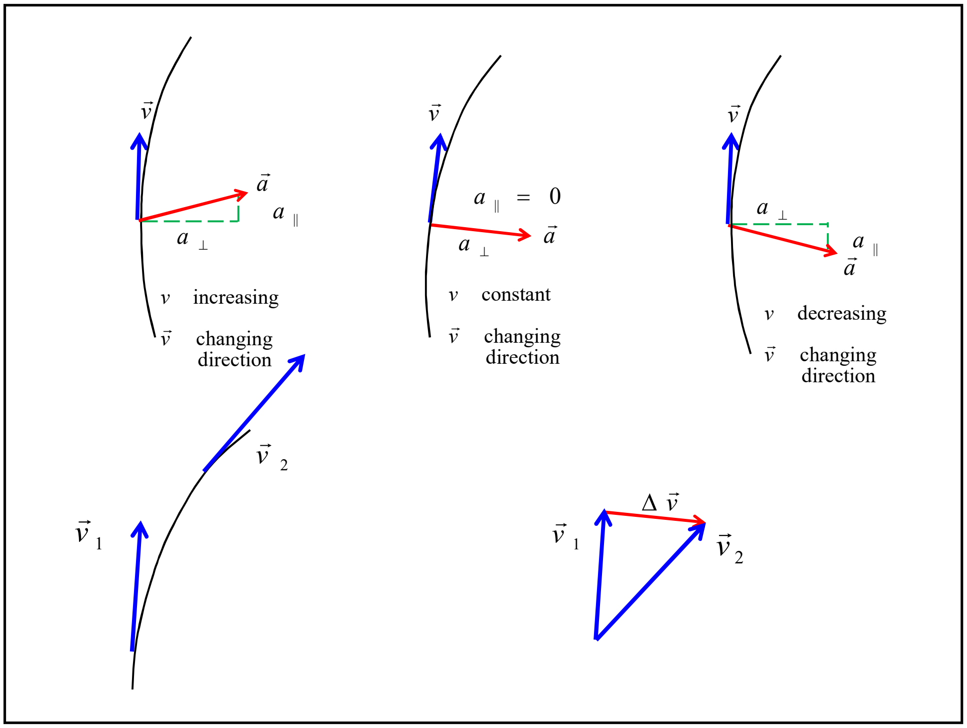
Clicker Question

A car drives around a circle of radius 10 m at a constant speed of 1 m/s. What is the magnitude of the car's acceleration, in m/s^2?

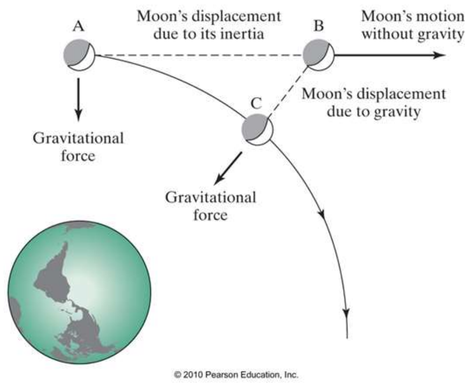
Clicker Question

A car drives around a circle of radius 10 m at a constant speed of 1 m/s. What is the magnitude of the car's acceleration, in m/s²?

$$a_{rad} = \frac{v^2}{R} = 0.1 \text{ m/s}^2$$



Newton’s Theory of Gravity



Newton saw a commonality between the motion of the moon and the motion of a falling apple.

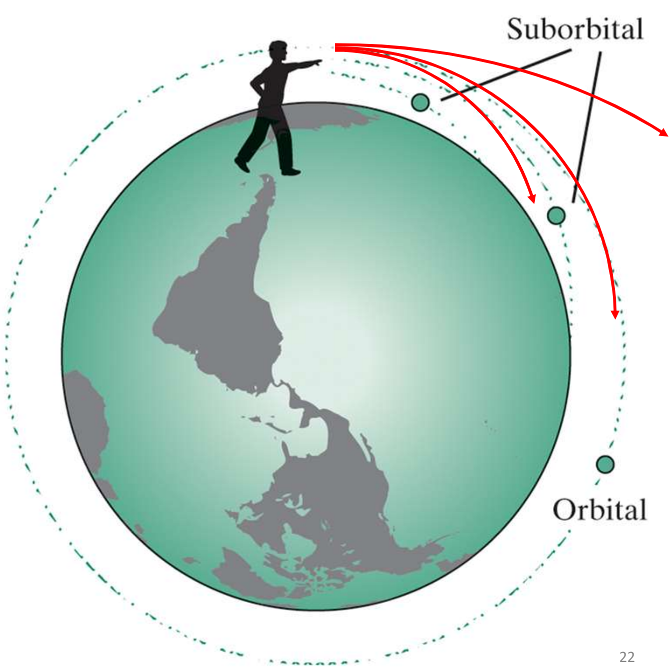
Think about the direction of the acceleration of the moon – the direction of its change in velocity – we see it points towards the Earth just as the apple’s acceleration does.

Is the apple falling?

Is the moon falling?

How can the same force make one object move in a circle and another fall down? Imagine throwing an apple horizontally. The faster you throw it, the farther it goes.

Now take this to the extreme, remembering that the earth is a sphere. If the apple goes horizontally fast enough, it will be in orbit – falling all the time.



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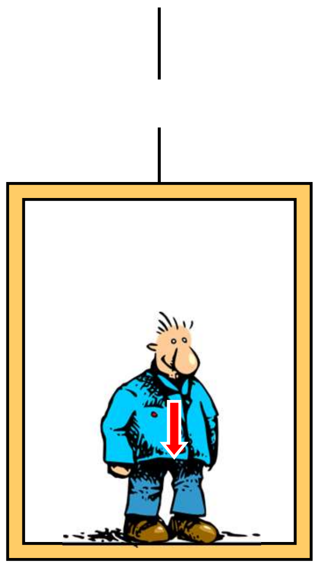
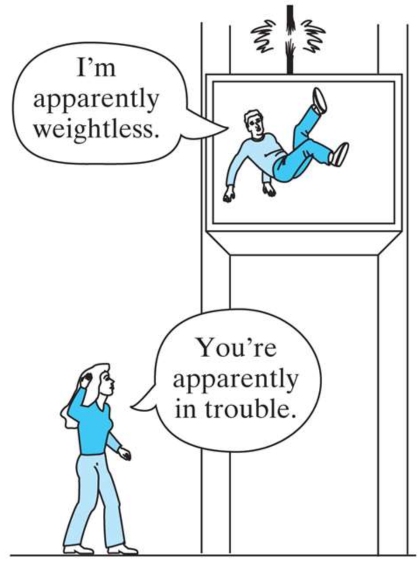
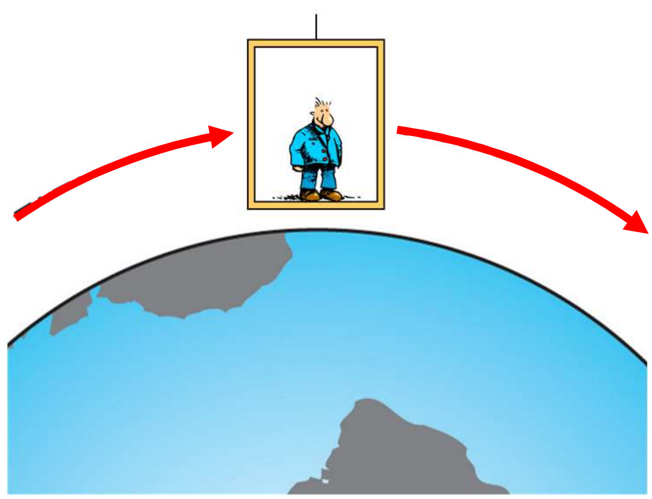




Is he weightless?

Does he feel weightless?



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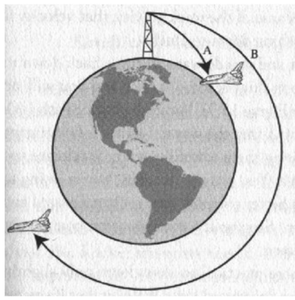
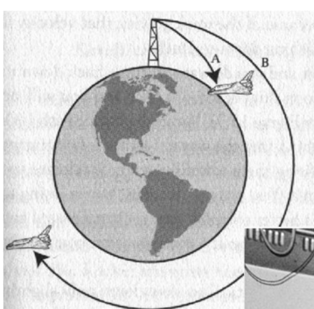


Satellites shot from a tower.
e.g. Satellite B launched with a velocity of 8 km/s, and satellite A had a lesser velocity.

Good numbers to know:

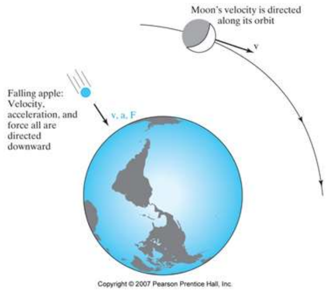
Orbital velocity: 5mi/s or 8km/s
Escape velocity: 7mi/s or 11km/s

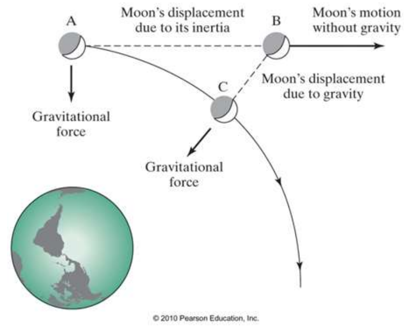


Why do astronauts experience weightlessness?

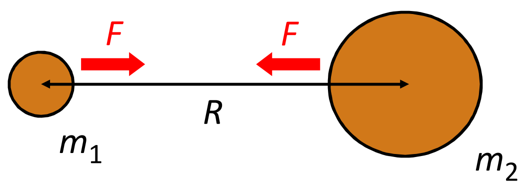
The answer is that, although the gravitational force on them is not zero, they are "falling" around the earth. They appear to be weightless because they are in free fall, as is the spacecraft around them.

Newton’s Theory of Gravity



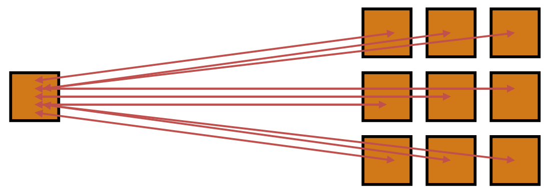


Newton’s Hypothesis:
All matter attracts all other matter via some universal law of gravitation



Newton guessed:

- Forces are ***equal*** and opposite
- Forces are proportional to masses



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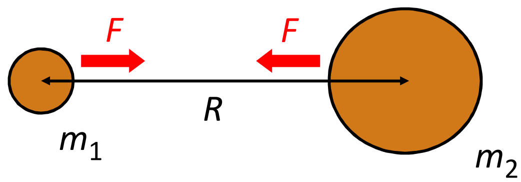
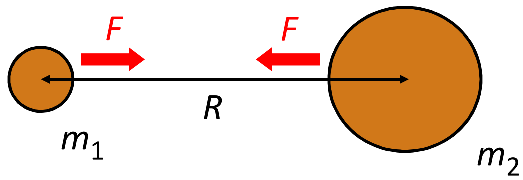


Newton guessed:

- Forces are ***equal*** and opposite
- Forces are proportional to both masses
- Forces decrease with distance
- Distance should be measured from body center to body center

Newton’s Hypothesis:
All matter attracts all other matter via some universal law of gravitation



$$F = G \frac{m_1 m_2}{R^X}$$

$F=m_1 a_1$

X = 1? 2 ? 3 ?

Newton’s Hypothesis:
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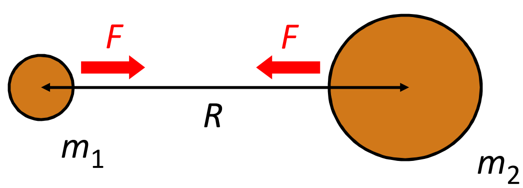

$$a_1 = G \frac{m_2}{R^X}$$

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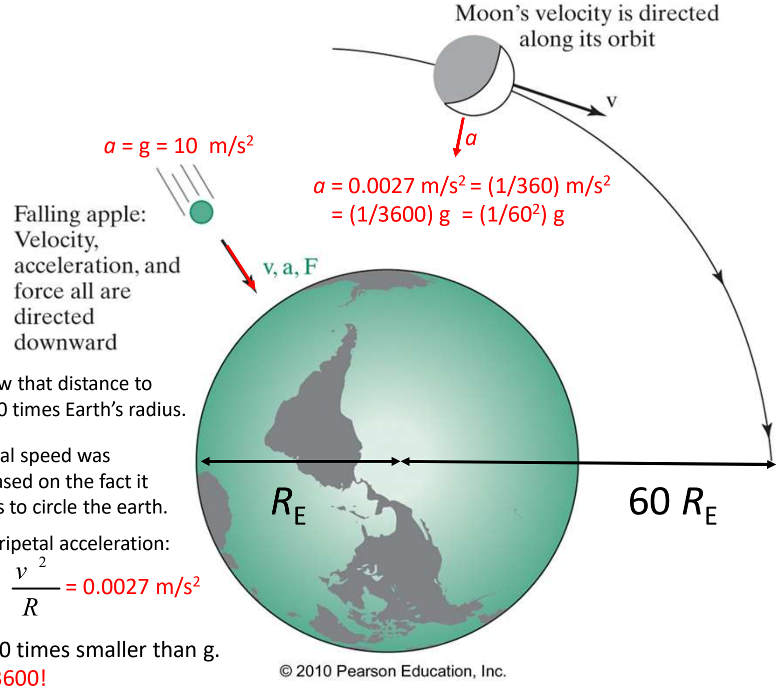


Newton knew that distance to moon was 60 times Earth's radius.

Moon's orbital speed was calculated based on the fact it takes 27 days to circle the earth.

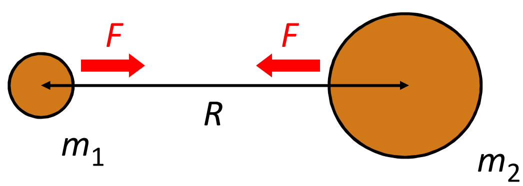
Moon's centripetal acceleration:

$$a_{rad} = \frac{v^2}{R} = 0.0027\ m/s^2$$

This is 3600 times smaller than g.

60 x 60 = 3600!

Newton's Universal Law of Gravitation



$$F = G\frac{m_1 m_2}{R^2}$$

$$G = 6.67 \times 10^{-11}\frac{Nm^2}{kg^2}$$ gravitational constant

Force is inversely proportional to the square of distance