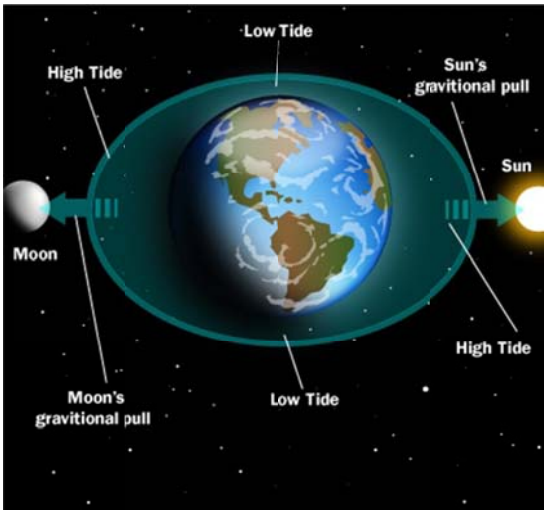


A1. The gravitational force of the moon and sun play an important role in the tides. When the sun, earth, and moon are in a straight line, their combined gravitational pull causes extra high and low tides known as spring tides. Whenever there is a full or new moon this occurs. The neap tides form when the sun, the earth, and the moon form a right angle, causing a half moon. The question is which, the sun or the moon, has the stronger gravitational pull?

Mass of Earth: 5.98×10^{24} Kg
Mass of Sun : 1.98×10^{30} Kg
Mass of Moon: 7.36×10^{22} Kg
Distance - Earth to Sun: 1.50×10^{11} m
Distance - Earth to Moon: 3.84×10^{8} m

A2. Jeremy ran 2 kilometers East, then 3 kilometers North, then another 2 kilometers East and finally 5 kilometers South. How far away from his original position is he (straight line distance)? Start by drawing a picture (graph) of his movement.

A3. You are on an unknown world. You have barely landed your spaceship safely but have spent the following several days exploring the planet surface. You found many interesting things on your excursions, including a rock shaped like a guitar and numerous quick sand pits. It is time to go home. You've notices some damage on one of the engines and the onboard computer informs you that you have only 60% maximum boost available.
Is this enough to lift you off the surface?

Mass of spaceship: 2400 kg
Mass of planet: 1.8987×10^{25} kg
Radius of planet: 8589.34 km
Maximum boost: 70 000 Newton

A4. Balance the see-saw! (See Mr. Čulig for details)

A5. You are still working as a freelance adrenalin park designer. Your boss has ordered a Rainbow Ride (see image for details). A Rainbow ride has a bench which is always leveled with the ground even as the big arm swings around in circles. This is one of the less exciting rides in the park and the owners don't want people flying off the top.
Question is: If the length of the big arms is 21 meters, how fast does it have to swing for the riders to feel weightless when reaching the top, but that they don't fly off?

B1. Come up with one experiment to demonstrate Newton's first law of motion (You can use the internet to browse for ideas). Explain exactly how it demonstrates the law.

B2. Come up with an experiment to demonstrate Newton's second law of motion (You can use the internet to browse for ideas). Explain exactly how it demonstrates the law.

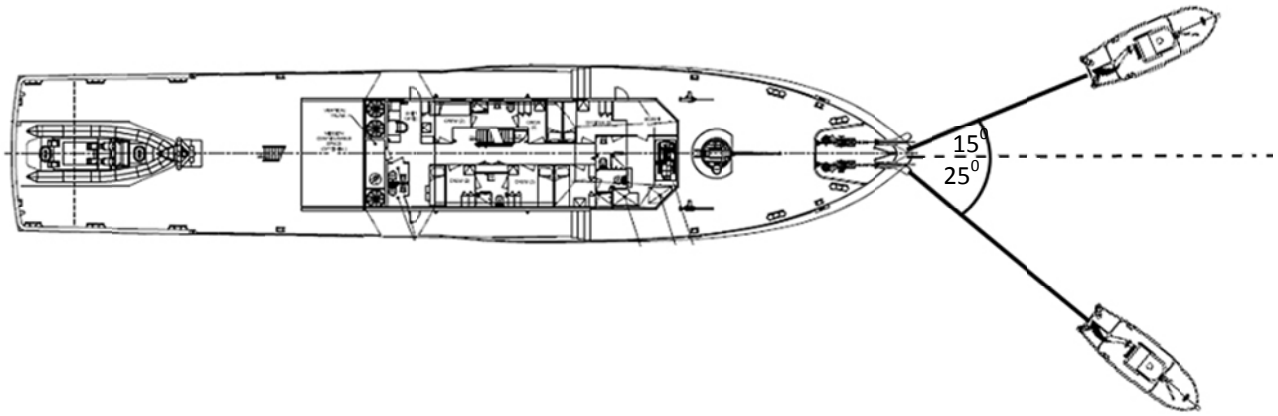
B3. Come up with an experiment to demonstrate Newton's third law of motion (You can use the internet to browse for ideas). Explain exactly how it demonstrates the law.

B4. If you're repairing the International Space Station and you lost a bolt, where would it end up? There are about 3000 man-made satellites orbiting the Earth. Often times they lose little bits and pieces. What happens to all that debris? (Use the internet to explore this issue)

B5. Find the acceleration of gravity for each of the planets in the Solar System. Compare this to their size. What can we deduce about the composition of the planet from this information? (Use the internet to do the research).

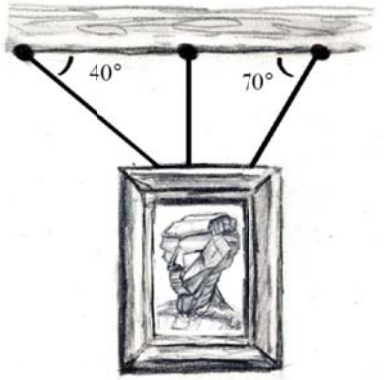
C1. Two tug boats are tugging a larger boat in the harbor. The forces and angles are as indicated on the picture. What is the net force on the boat?

$\overrightarrow{F_1} = 10\,000\ N$



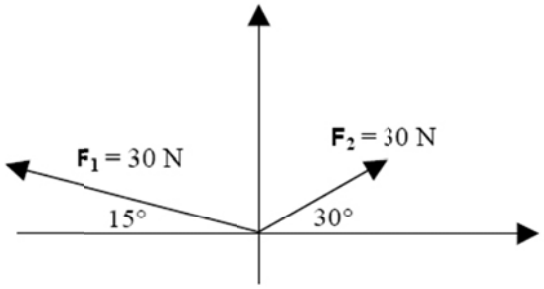
$\overrightarrow{F_2} = 12\,000\ N$

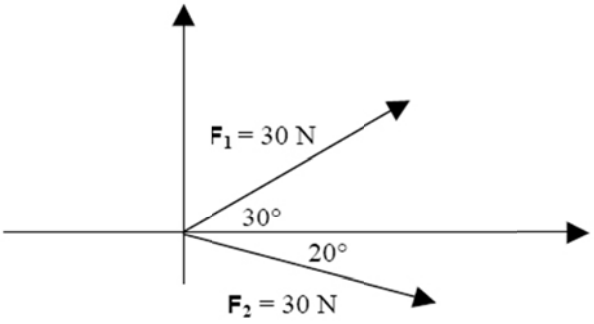
C2. Find the mass of the painting. The tension in the leftmost rope is 7.2 N, in the middle rope it is 16 N, and in the rightmost rope it is 16 N.



C3. In a tug-of-war, 6 students, with an average mass of 75 kg each, pull westward on a rope with an average force of 400 N per student. An elephant, with a mass of 3900 kg, pulls eastward on the other end of the rope with a force of 2000 N. Assuming that the whole mass accelerates together as a single entity, what is the acceleration of the system? (Hint: Apply Newton's laws of motion.)

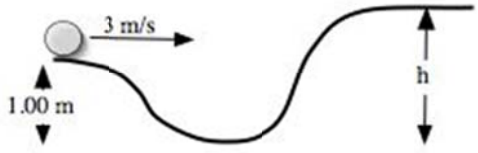
C4. Find the net force for the following situations:





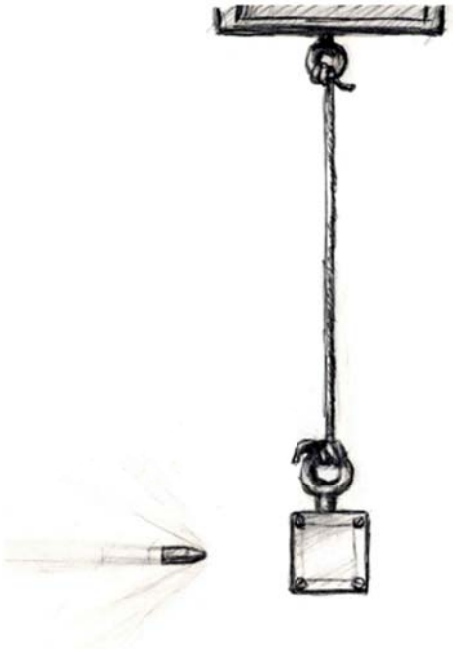
C5. A Merry-go-round has a radius of 15 meters. It is spinning around at a rate of 10 times per minute. At what angle will the riders be while the ride is running?

D1. A cart moving along a track 1.00 m above the floor at 3 m/s eventually reaches a higher plateau What is the maximum height of the plateau above the floor?

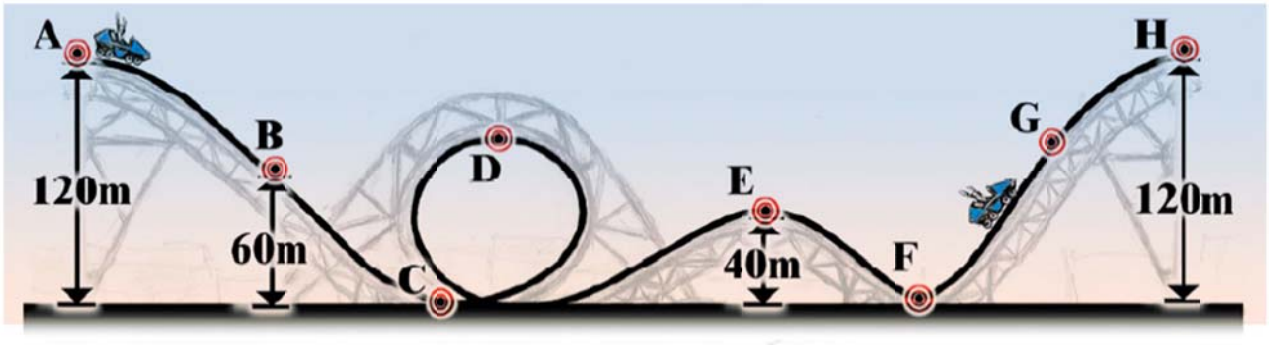


D2. The 20 g bullet shown below is travelling to the right with a speed of 20 m/s. A 1.0 kg block is hanging from the ceiling from a rope 2.0 m in length.

a) What is the maximum height that the bullet-block system will reach, if the bullet embeds itself in the block?
b) What is the maximum angle the rope makes with the vertical after the collision?



D3. Tarzan runs up to a jungle vine at a speed of 10 m/s. He weighs 92 kg. How high can he expect to swing?



D4. A roller coaster begins at rest 120 m above the ground, as shown. Assume no friction from the wheels and air, and that no energy is lost to heat, sound and so on. The radius of the loop is 40 m.

a) Find the speed of the roller coaster at points B, C, D, E, F and H.
b) Assume that 25% of the initial potential energy of the coaster is lost due to heat, sound, and air resistance along this route. How far short of point H will the coaster stop?
c) Does the coaster actually make it through the loop without falling?

D5. A spring has been compressed by 50 cm and a 70 kg person has been loaded on top of it. If the value of the spring constant is k = 50 000 N/m, how high will the person fly when the spring is released?