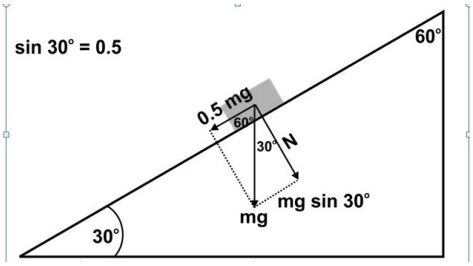
1. How much force is needed to accelerate a 1.6 kg mass moving at 10 meters per second up to 42.8 meters/sec in 2.9 seconds?

(A) 18.1 kg-m/sec^2 (newtons)
(B) 18.5 kg-m/sec^2 (newtons)
(C) 19.1 kg-m/sec^2 (newtons)
(D) 19.5 kg-m/sec^2 (newtons)
(E) 20.1 kg-m/sec^2 (newtons)

2. How many meters does it take to stop a car weighing 1700 kilograms and traveling at 115 kilometers per hour if the driver takes 0.6 seconds to slam on the brakes and the car then decelerates at a rate of 8 meters per second?
(A) 61 m
(B) 66 m
(C) 71 m
(D) 76 m
(E) 83 m

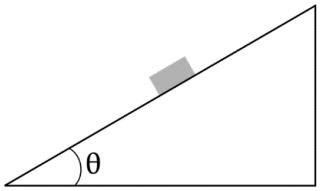
3. What is the magnitude of the force causing the block to slide down this frictionless incline?



(A) mg cos 30^o
(B) mg tan 30^o
(C) mg sin 30^o
(D) mg/sin 30^o
(E) mg/cos 30^o

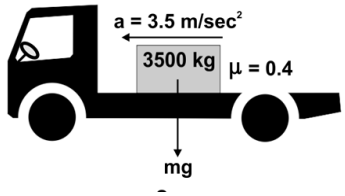
4. Here is a block sitting on an incline where there is friction between by the block and surface of the incline measured by the coefficient of static friction, mu.

Whether the block starts sliding depends on which of the following?



(A) the mass of the block alone
(B) the mass of the block and the angle of incline
(C) the mass of the block, the angle of incline, and the coefficient of static friction
(D) the angle of incline and the coefficient of static friction
(E) the mass of the block and the coefficient of static friction

5. A flatbed truck carrying a 3500 kilogram load suddenly slams on the brakes, decelerating the truck at 3.5 meters per second squared. The coefficient of static friction for the object is 0.4. Will the load slide forward?

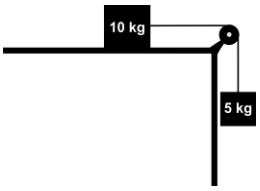


(A) yes
(B) no
(C) it depends

6. This 5 kilogram block is pulling a 9 kilogram block across a frictionless table top. What is the downward acceleration of the 5 kilogram block?

(A) 3.1 m/sec^2
(B) 3.2 m/sec^2
(C) 3.3 m/sec^2
(D) 3.4 m/sec^2
(E) 3.5 m/sec^2

7. Suppose a 10 kg block is being pulled along a regular tabletop with friction by another, smaller block of 5 kg, which is accelerating downward at a rate of 1.5 meters per second squared. What is the coefficient of friction between the 10 kilogram block and table top?

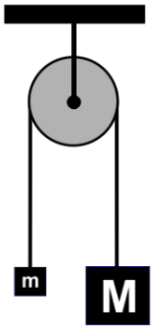


(A) 2.9
(B) 0.27
(C) 29.0
(D) 4.4
(E) 0.56

8. The Navy rescues a 100 kg victim from the sea. How strong does the cable have to be to support both men weighing 200 kg total if the helicopter accelerates them upward at a rate of 5 meters per second squared?

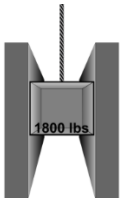
(A) 1400 N
(B) 1050 N
(C) 2960 N
(D) 1480 N
(E) 1240 N

9. Here are two blocks suspended over a pulley. One block has a mass of 1 kg and the other a mass of 3 kg. Since the two blocks are connected to each other, they must accelerate at the same rate. What is the acceleration of the two blocks, and how many newtons of tension must the rope be able to withstand?



(A) 0.5 g, 14.7 N
(B) 1 g, 14.7 N
(C) 1.5 g, 22.1 N
(D) 2.0 g, 22.1 N
(E) 2.5 g, 14.7 N

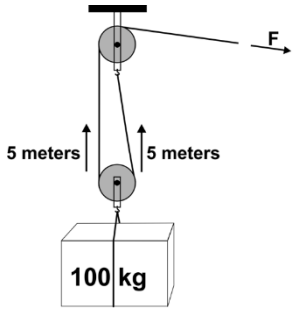
10. How much force is required to accelerate an 1800 lb. elevator upward at 20 feet per second squared?



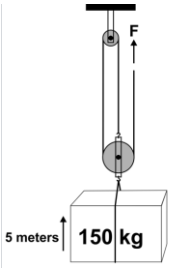
(A) 2725 lbs
(B) 2925 lbs
(C) 3155 lbs
(D) 3530 lbs
(E) 4075 lbs

11. How much force must be exerted on the rope to lift this 100 kg block and how many meters of rope must be pulled to lift the block 5 meters?

(A) 100 newtons, 5 meters
(B) 980 newtons, 5 meters
(C) 980 newtons, 10 meters
(D) 490 newtons, 10 meters
(E) 490 newtons, 5 meters

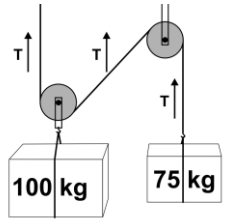


12. How much force must be exerted to lift this 150 kg block and how many meters of rope must be pulled to lift the block 5 meters?



(A) 1470 newtons, 5 meters
(B) 500 newtons, 15 meters
(C) 1470 newtons, 15 meters
(D) 490 newtons, 15 meters
(E) 490 newtons, 5 meters

13. When these two boxes are allowed to fall, what is the acceleration of the 75 kilogram box and what is the tension in the rope?



(A) a = 2.5 m/sec^2, T = 547.5 N
(B) a = 2.7 m/sec^2, T = 538.3 N
(C) a = 2.9 m/sec^2, T = 533.6 N
(D) a = 3.1 m/sec^2, T = 529.8 N
(E) a = 3.3 m/sec^2, T = 525.4 N

Introduction to Question 14

Centripetal acceleration is tangential velocity squared divided by the radius, and centripetal force is mass times centripetal acceleration.

When driving a car around a sharp curve, centripetal force is the mass of the car times centripetal acceleration. Where is the centripetal force coming from?

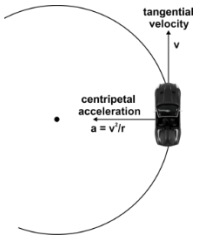
The centripetal force comes from the force of friction of the tires with the road. The magnitude of the force of friction is the weight of the car times the coefficient of friction, mu. F = m g mu (F = mgμ).
Since mv squared (mv^2) and mgμ are both centripetal force, they equal each other.
mgμ = mv^2/r.

What this equation says is that when making a curve, stepping on the gas and increasing the car's speed does increase centripetal acceleration and pull the car

inward toward the center of curvature, but the reason stepping on the gas while making a curve is not a good idea is that in order for the car to maintain a circular path, the car's frictional force, mass times g times mu, has to keep up with mv^2/r. Because mv^2/r increases by the square of the velocity, it doesn't take much of an increase in velocity before the car's centripetal force overcomes the force of friction holding the tires to the pavement, and the car begins skidding off the road.

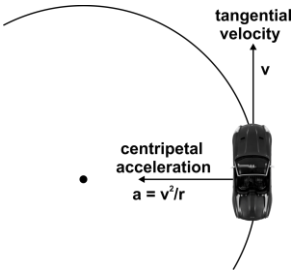
The same goes for trying to make a sharper curve to increase centripetal acceleration. Yes, the tighter you make the curve, the small r becomes and the greater the centripetal acceleration, but mgμ still has to keep up in order to keep the car from sliding off the road.

14. If the coefficient of friction for rubber on concrete is 0.7, will this 2240 kg car traveling at 108 kilometers per hour around a 100 meter radius curve hold the road or skid?



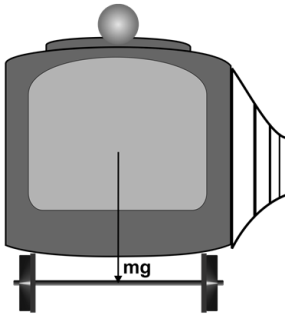
(A) yes
(B) no
(C) it depends

15. How much does the driver of the car have to reduce his speed in order for it not to skid off the road?



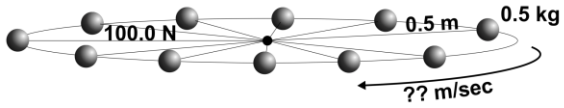
(A) 10 km/hr
(B) 11 km/hr
(C) 12 km/hr
(D) 13 km/hr
(E) 14 km/hr

16. To prevent this train from slipping off the tracks when it makes a curve, the railroad tracks can be banked. The two factors that determine the optimal angle of bank are the expected speed of the train and the radius of curvature of the railroad track. Which formula describes the optimal angle?



(A) sine angle = $mv^2/r\ g$
(B) sine angle = $v^2/r\ g$
(C) cos angle = $v^2/r\ g$
(D) tan angle = $v^2/r\ g$
(E) tan angle = $mv^2/r\ g$

17. If a 0.5 meter rope that can only withstand 100 newtons of tension before snapping is used to spin a 0.5 kg rock in a horizontal circle, what is the maximal speed that the rock can be spun before the rope snaps?



(A) 5 meters per second
(B) 10 meters per second
(C) 15 meters per second
(D) 20 meters per second
(E) 25 meters per second

Introduction to Question 18

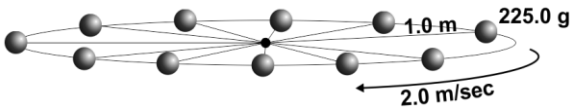
Here is a 225 gram ball in outer space being swung in a circle by a 1 meter long string at a velocity of 2 meters per second.

What happens when you try to do this on earth?

The ball drops slightly because of gravity. You can never swing a ball higher than the plane of your hand like a cowboy swinging a lasso.

The weight of the ball will always pull the spinning ball below the level of your

hand. Here is a 225 gram ball in outer space being swung in a circle by a 1 meter long string at a velocity of 2 meters per second.



What happens when you try to do this on earth?

The ball drops slightly because of gravity. You can never swing a ball higher than the plane of your hand like a cowboy swinging a lasso. The weight of the ball will always pull the spinning ball below the level of your hand.

Notice also that swinging a ball on earth shortens the radius of the curvature, r, a bit, because the string is still only 1 meter long.

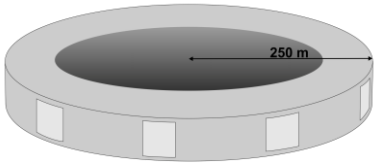
18. Does the string on earth experience extra tension because the ball is now rotating at a lower level than your hand?

Yes, because if the ball's tangential velocity is to remain at 2 meters per second, the shorter radius means that the centripetal force must increase. But by how much?

(A) the string tension in outer space is 0.9 N, on earth 2.1 N
(B) the string tension in outer space is 0.9 N, on earth 2.4 N
(C) the string tension in outer space is 0.9 N, on earth 2.7 N
(D) the string tension in outer space is 0.9 N, on earth 3.0 N
(E) the string tension in outer space is 0.9 N, on earth 3.3 N

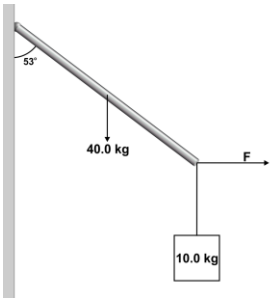
19. Space stations revolve in order to create a centripetal acceleration equal to the acceleration of gravity, 9.8 meters per second squared.

For a space station with a radius of 250 meters to have the acceleration of gravity, in what period of time must it complete one revolution, and what is its tangential velocity?



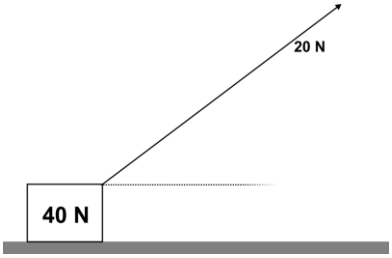
(A) time = 43.7 sec, velocity 55.5 m/sec
(B) time = 51.3 sec, velocity 39.3 m/sec
(C) time = 39.8 sec, velocity 51.7 m/sec
(D) time = 38.2 sec, velocity 59.6 m/sec
(E) time = 31.7 sec, velocity 49.5

20. A steel rod with a mass of 40 kilograms is hinged to a wall at a 53 degree angle to the wall. The free end is held in the air by a horizontal wire. The free end is holding up a 10 kg mass. How much force is the horizontal wire using to hold up the free end of the rod?



(A) 392 N
(B) 401 N
(C) 408 N
(D) 422 N
(E) 444 N

21. A 40 newton block of wood is being dragged across a wooden floor by a rope at a 37 degree angle. It takes 20 newtons of force to get the block moving. What is the coefficient of static friction, mu, of the floor?



(A) 0.40
(B) 0.43
(C) 0.49
(D) 0.54
(E) 0.57