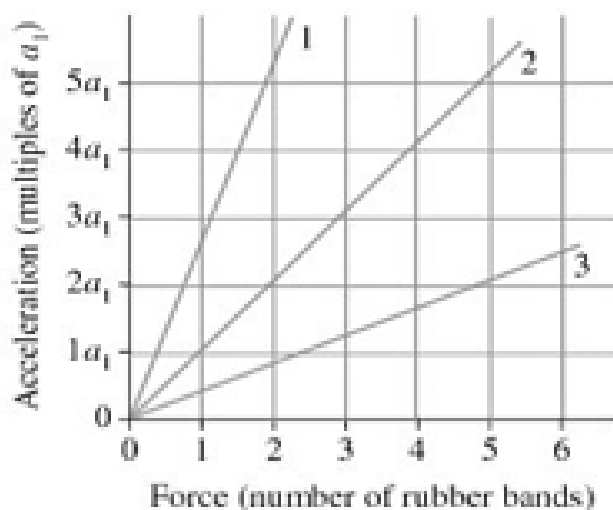


1. The figure shows an acceleration-versus-force graph for three objects pulled by rubber bands. The mass of object 2 is 36 kg. What are the masses of objects 1 and 3?



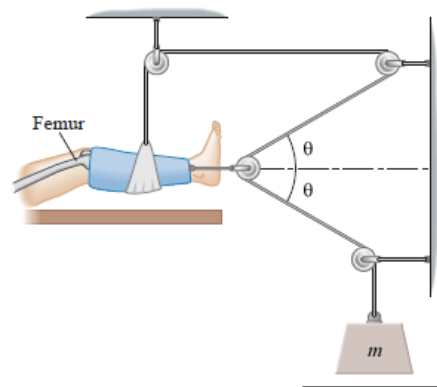
- A) 14 kg and 90 kg
 B) 72 kg and 18 kg
 C) 90 kg and 18 kg
 D) 14 kg and 72 kg

2. An 1100-kg car traveling at 27.0 m/s starts to slow down and comes to a complete stop in 578 m. What is the magnitude of the average braking force acting on the car?
- A) 690 N
 B) 550 N
 C) 410 N
 D) 340 N
3. John Lester is at the park practicing his pitching. Since he doesn't have a catcher, John wants to pitch the ball all the way around the Earth so he can catch it himself. Neglecting air drag and any obstacles that might be in the way, about how fast must the ball be moving? You may take the radius of the Earth to be 6400 km.
- A) 9.8 m/s
 B) 250 m/s
 C) 1100 m/s
 D) 8000 m/s
 E) 6×10^7 m/s

4. When she comes out of the grocery store, Guy's mother-in-law puts her 3 kg bag of groceries on top of the roof while she unlocks the car and climbs into the driver's seat, forgetting about the groceries on the roof. If the coefficient of static friction between the groceries and the roof is 0.8, approximately what is the maximum acceleration she can have before the bag starts to slide?

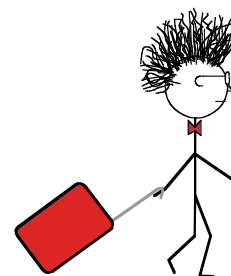
A) 8 m/s^2
 B) 10 m/s^2
 C) 12 m/s^2
 D) 20 m/s^2
 E) 24 m/s^2

5. Mr. Luckless, who was riding to the grocery store with Guy's mother-in-law, is now in the hospital with a broken leg. His leg is in traction as shown in the figure. What is the magnitude of the net horizontal force that the rope exerts on the leg?



A) $mg \cos \theta$
 B) $mg \cos(2\theta)$
 C) $mg \tan \theta$
 D) $2mg \tan \theta$
 E) $2mg \cos \theta$

6. Albert is at the airport. He is dragging his suitcase behind him at a steady speed as shown. The coefficient of friction between the suitcase and the ground is μ , the mass of the suitcase is m , and the strap makes an angle θ with the horizontal. What is the tension in the strap?

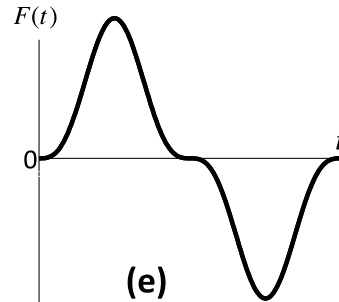
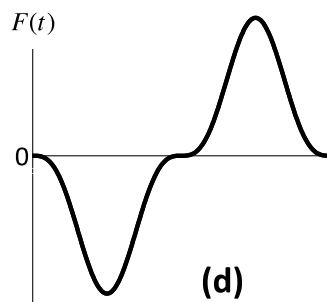
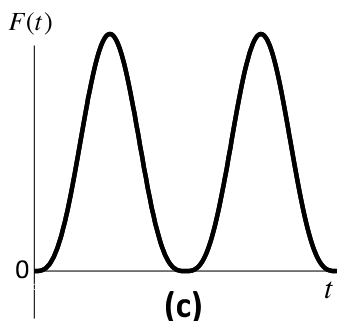
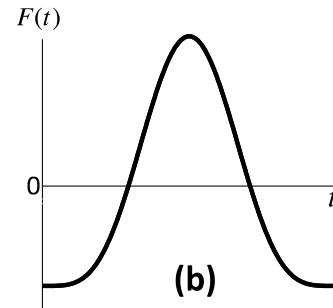
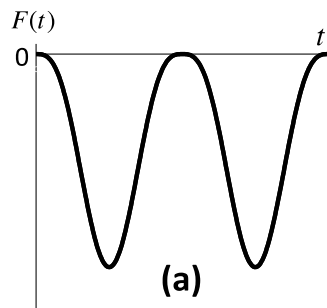
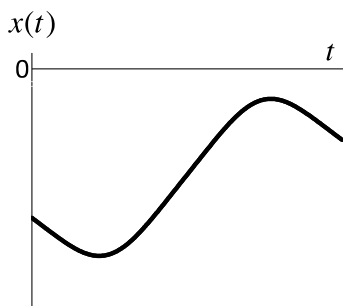


A) $\frac{\mu mg}{\sin \theta + \mu \cos \theta}$
 B) $\mu mg(1 + \tan \theta)$
 C) $mg(1 + \mu \tan \theta)$
 D) $\frac{\mu mg}{\mu \sin \theta + \cos \theta}$
 E) $mg(\sin \theta + \mu \cos \theta)$

7. Tiger Woods is playing shuffleboard. (Shuffleboard is a game where the participant gives a disk a push along a polished wooden floor to score points.) He wants the disk to slide to a stop a distance D away. If the coefficient of kinetic friction between the disk and the deck is μ , what initial speed should he give the disk?

- A) $2gD\mu$
- B) $\frac{1}{2}gD^2$
- C) $\mu\sqrt{gD}$
- D) $\sqrt{2gD\mu}$
- E) $\frac{1}{2}\sqrt{gD\mu}$

8. The motion of a particle in one dimension is graphed in the upper left figure (below). Which of the other five graphs best represents the net force as a function of time $F(t)$ on the particle?



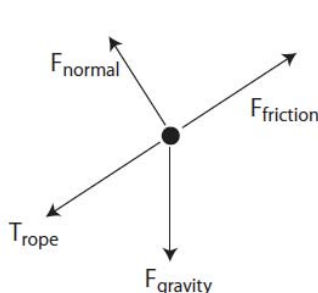
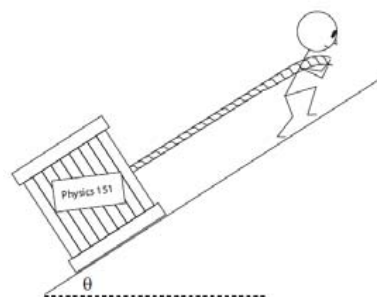
9. An egg crate of mass m sits on the floor of a flatbed truck, which is at rest at the starting line of a race. The truck suddenly accelerates with constant acceleration a until it reaches a velocity v , and then continues at that velocity. The coefficient of static friction between the box and truck bed is μ_s and the coefficient of kinetic friction is μ_k . Which of the following conditions must be satisfied so that the egg crate stays at rest on the truck?
- A) $a < \mu_s mg$
 - B) $v < \mu_s g$
 - C) $v < 2\mu_s mg$
 - D) $a < \mu_s g$
 - E) $a < \mu_k mg$
10. Buzz Aldrin is riding his lunar module “The Falcon” down to the moon’s surface. He is wearing his backpack, which weighs 1300 N on Earth. During the descent, he is decelerating at a rate of 1.0 m/s^2 . What is the apparent weight of his backpack during the descent? (It may be helpful to know that the acceleration due to gravity on the moon is $1/6^{\text{th}}$ the value it is on Earth. Also, keep in mind that *apparent weight* refers to how heavy the backpack feels to Buzz Aldrin.)
- A) 20 N
 - B) 80 N
 - C) 220 N
 - D) 350 N
 - E) 1300 N
11. When a car goes around a curve (without skidding), on a level road,
- A) no friction force is needed because the car simply follows the road.
 - B) the friction force of the road on the car increases when the car’s speed decreases.
 - C) the friction force of the road on the car increases when the car’s speed increases.
 - D) the friction force of the road on the car increases when the car moves to the outside of the curve.
 - E) there is no net friction force because the road and the car exert equal and opposite forces on each other.

12. Two bodies P and Q on a smooth horizontal surface are connected by a light cord. The mass of P is greater than that of Q. A horizontal force (of magnitude F) is applied to Q as shown in the figure, accelerating the bodies to the right. The magnitude of the force exerted by the connecting cord on body P will be:

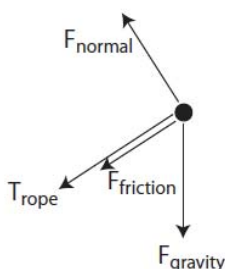


- A) zero.
- B) less than F but not zero.
- C) equal to F .
- D) greater than F .

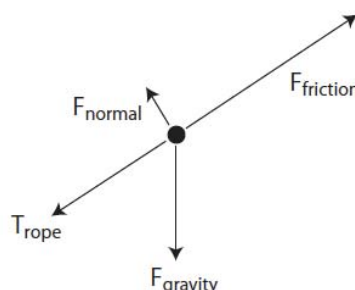
13. Sisyphus is pulling a box up an inclined plane at a constant speed. Which free body diagram correctly displays the forces ON SISYPHUS? Remember to pay attention to both the direction and the magnitude of the vectors.



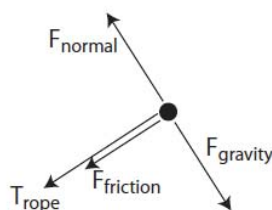
A)



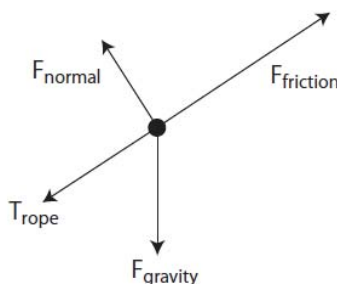
B)



C)



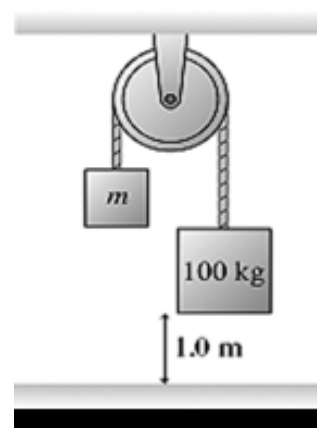
D)



E)

14. The figure shows a 100-kg block being released from rest from a height of 1.0 m. It then takes it 0.90 s to reach the floor. What is the mass m of the other block? The pulley has no appreciable mass or friction.

A) 60 kg
 B) 54 kg
 C) 48 kg
 D) 42 kg



15. A 6.00-kg block is in contact with a 4.00-kg block on a horizontal frictionless surface as shown in the figure. The 6.00-kg block is being pushed by a horizontal 20.0-N force as shown. What is the magnitude of the force that the 6.00-kg block exerts on the 4.00-kg block?

A) 6.00 N
 B) 20.0 N
 C) 8.00 N
 D) 4.00 N
 E) 10.0 N

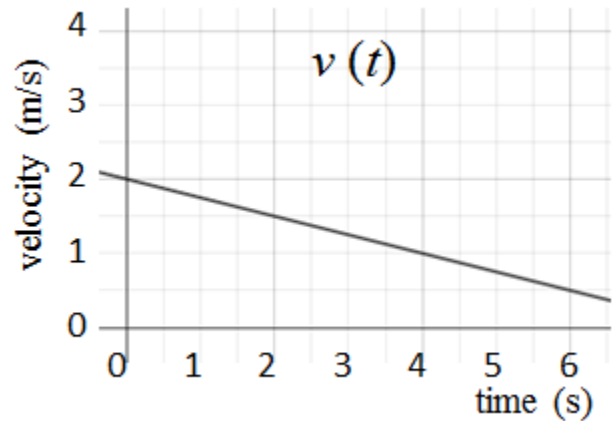


16. A car is travelling around a circle of radius 150 m at a constant speed. The circle is oriented horizontally on the xy -plane. At one instant during its motion, the car's acceleration is $\vec{a} = \langle -0.54, 1.1 \rangle \text{ m/s}^2$. How fast is the car travelling?

A) 11 m/s
 B) 14 m/s
 C) 17 m/s
 D) 20 m/s
 E) 23 m/s

17. A particle initially travelling at 3.5×10^4 m/s at 30° east of north feels a constant force from a magnetic field, and over the course of 0.015 s changes direction so that it ends up travelling 2.5×10^4 m/s at 50° west of north. What was the magnitude of the particle's average acceleration over this time interval? [The force from the magnetic field can be treated like any force acting on an object, subject to Newton's laws of motion.]
- A) 1.8×10^6 m/s²
 - B) 2.0×10^6 m/s²
 - C) 2.2×10^6 m/s²
 - D) 2.4×10^6 m/s²
 - E) 2.6×10^6 m/s²
18. If a car can accelerate uniformly from zero to 25 m/s in 9.5 seconds, what is the approximate angular acceleration of each of its 28 cm diameter tires while this is happening?
- A) 10 rad/s²
 - B) 20 rad/s²
 - C) 50 rad/s²
 - D) 100 rad/s²
 - E) 200 rad/s²
19. Through what angle in degrees does a 33 rpm record turn in 0.50 seconds? (*rpm* stands for rotations per minute and a *record* is a flat piece of plastic that turns at a constant rate around a fixed axis, similar to a DVD.)
- A) 100°
 - B) 90°
 - C) 80°
 - D) 70°
 - E) 60°

20. A bar of soap is sliding to the right across the floor of the bathroom. As it slides, it experiences a constant force of 0.35 N directed towards the left. The velocity of the bar of soap as a function of time is given on the graph shown. What is the mass of the bar of soap? [When reading the graph, consider positive velocity values to represent *rightward* motion for the bar of soap.]

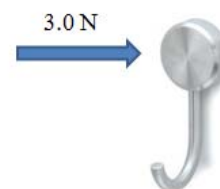


- A) 0.70 kg
 B) 1.0 kg
 C) 1.4 kg
 D) 1.7 kg
 E) 2.0 kg
21. Cooking an omelet on a boat is tricky because the tilting of the boat can cause the omelet to slip off the flat griddle. If the coefficient of static friction between the omelet and the griddle is 0.05 , what is the largest angle (measured from the horizontal) that the griddle can tilt before the omelet starts to slide?
- A) 3°
 B) 6°
 C) 9°
 D) 12°
 E) 15°

22. A 2 kg object is subjected to three horizontal forces that give it an acceleration $\vec{a} = \langle -8, 6 \rangle \text{ m/s}^2$. If two of the three forces are $\vec{F}_1 = \langle 30, 16 \rangle \text{ N}$ and $\vec{F}_2 = \langle -12, 8 \rangle \text{ N}$, what is the third force? [Note that the components of these vectors are on the horizontal xy -plane.]

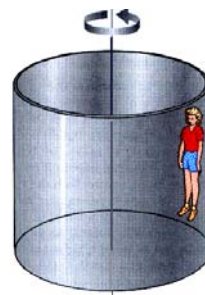
- A) $\langle -20, 14 \rangle \text{ N}$
- B) $\langle 18, 24 \rangle \text{ N}$
- C) $\langle 34, 12 \rangle \text{ N}$
- D) $\langle -18, -24 \rangle \text{ N}$
- E) $\langle -34, -12 \rangle \text{ N}$

23. A horizontal force (due to magnetic attraction) of 3.0 N is pulling a magnetic hook weighing 0.70 N against the side of a refrigerator. The coefficients of static and kinetic friction between the magnetic hook and the refrigerator are $\mu_s = 0.60$ and $\mu_k = 0.40$ respectively. What will happen when a 1.5 N oven mitt is hung from the magnetic hook?



- A) The mitt & magnet will slide down and the force of friction between the hook and refrigerator will be 1.2 N.
- B) The mitt & magnet will slide down and the force of friction between the hook and refrigerator will be 2.4 N.
- C) The mitt & magnet will not slide down and the force of friction between the hook and refrigerator will be 1.2 N.
- D) The mitt & magnet will not slide down and the force of friction between the hook and refrigerator will be 2.2 N.
- E) The mitt & magnet will not slide down and the force of friction between the hook and refrigerator will be 2.4 N.

24. While operating the Rotor Ride (a large, vertical, rotating cylinder found in amusement parks), you spot a passenger who needs to get off the ride as quickly as possible; so you apply the brakes, resulting in a constant angular deceleration. While the ride is slowing down, you happen to notice the passenger rotated 20.0 revolutions as the ride's turning decreased from 3.40 rad/s to 2.00 rad/s. If the ride continues to slow down at this rate, how much more time after that does it take before the ride completely stops? [Be careful of units.]

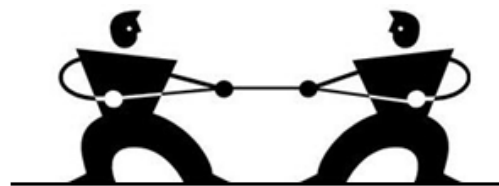


- A) 21 s
 - B) 35 s
 - C) 42 s
 - D) 53 s
 - E) 66 s
25. A satellite orbits the earth a distance of 1.50×10^7 m above the planet's surface and takes 8.65 hours for each revolution about the earth. The earth's radius is 6.38×10^6 m. The acceleration of this satellite is closest to:
- A) 0.0690 m/s².
 - B) 0.870 m/s².
 - C) 1.91 m/s².
 - D) 2.72 m/s².
 - E) 9.80 m/s².

26. You are making a circular turn in your car (while on a horizontal road) when you hit a big patch of ice, causing the force of friction between the tires and the road to become zero. While the car is on the ice, your car

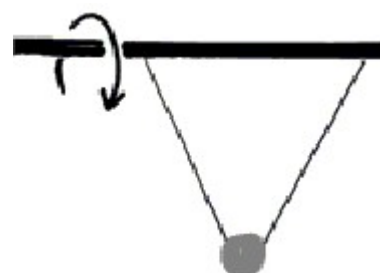
- A) moves along a path that is neither straight nor circular.
- B) continues to follow a circular path, but with a radius larger than the original radius.
- C) continues to follow the same circular path as initially.
- D) continues to follow a circular path, but with a radius smaller than the original radius.
- E) moves along a straight-line path.

27. Jill and Bill are pulling on opposite ends of a rope. Jill is pulling with a force of 300 N. Bill is simply hanging on, but skidding towards Jill at a constant velocity. What is the force of friction between Bill's feet and the ground?



- A) Less than 300 N
- B) 300 N
- C) Greater than 300 N, but less than 600 N
- D) 600 N
- E) More than 600 N

28. A ball is connected by two massless strings to a horizontal, rotating rod, and moves in a vertical circle. The strings are tied to the rod, are taut, and form two sides of an equilateral triangle. A "photograph" of the system is taken at moment t_0 and shown in the figure. At t_0 the centripetal acceleration of the ball



- A) is vertical and points upward.
- B) is vertical and points downward.
- C) is horizontal and points left.
- D) is horizontal and points right.
- E) does not depend on the speed of rotation.

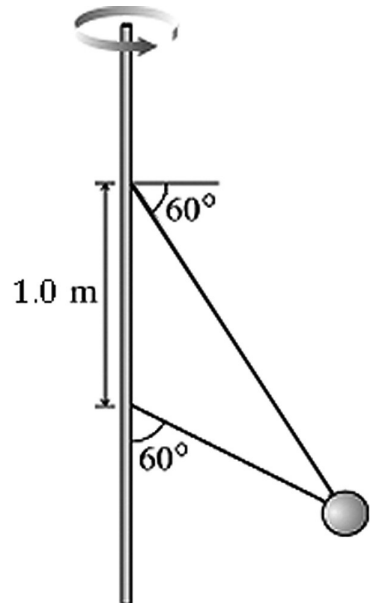
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12	
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28	

9) Engineers are designing a curved section of a highway. If the radius of curvature of the curve is 194 m, at what angle should the curve be banked so that a car traveling at 29.0 m/s will stay on the road without the aid of frictional forces?

- A) 23.9°
- B) 16.7°
- C) 21.0°
- D) 26.1°

Answer: A

10) The figure shows two wires tied to a 3.3 kg sphere that revolves in a horizontal circle at constant speed. At this particular speed the tension is the SAME in both wires. What is the tension?



- A) 24 N
- B) 32 N
- C) 44 N
- D) 22 N

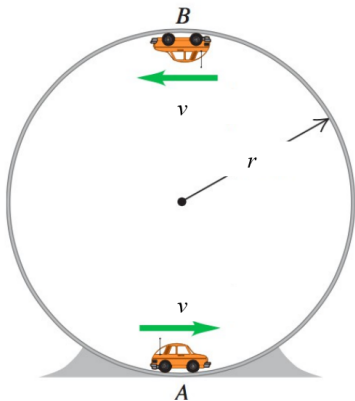
Answer: A

2) A car travels at a steady 40.0 m/s around a horizontal curve of radius 200 m. What is the minimum coefficient of static friction between the road and the car's tires that will allow the car to travel at this speed without sliding?

- A) 1.23
- B) 0.816
- C) 0.736
- D) 0.952
- E) 0.662

Answer: B

A small car with mass 0.80 kg travels at constant speed on the inside of a track whose shape is a vertical circle. If the normal force exerted by the track on the car when it is at the top of the track (point B) is 6.0 N, what is the normal force on the car when it is at the bottom of the track (point A)?



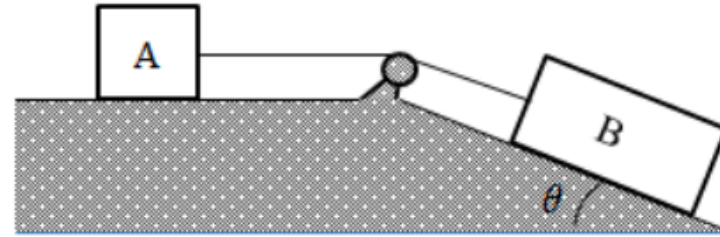
- A) 6.0 N
- B) 12 N
- C) 16 N
- D) 19 N
- E) 22 N (answer)

2. A police officer in hot pursuit of a criminal drives her car through an unbanked circular (horizontal) turn of radius 300 m at a constant speed of 22.2 m/s. Her mass is 55.0 kg. To the nearest degree, what is the angle (relative to vertical) of the net force of the car seat on the officer? [Hint: Consider both horizontal and vertical forces.]

A) 0°
B) 7°
C) 10°
D) 13°
E) 90°

Answer = C

3. In the figure, block A of mass $m_A = 2.0$ kg and block B of mass $m_B = 3.0$ kg are connected by a string of negligible mass and are initially held in place. Block B

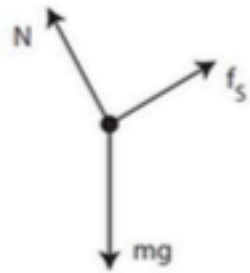
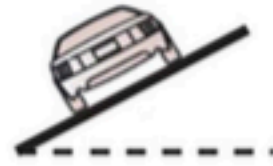


is on a frictionless surface tilted at $\theta = 30^\circ$ from the horizontal. The coefficient of kinetic friction between block A and the horizontal surface is 0.25. The pulley has negligible mass and friction. Once they are released, the blocks move. While they are moving, what is the tension in the string?

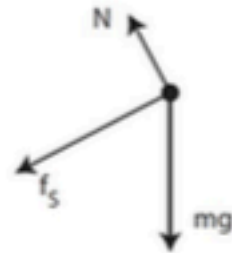
A) 1.6 N
B) 3.2 N
C) 4.9 N
D) 6.5 N
E) 8.8 N

Answer = E

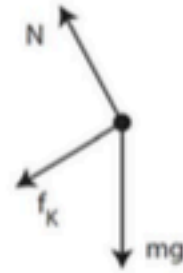
16. A car of mass m is driving around a banked curve at constant speed. The diagram at the right shows the car from behind as it's going around a curve whose center is to the left. Which of the diagrams below most correctly represents the free-body diagram for the car?



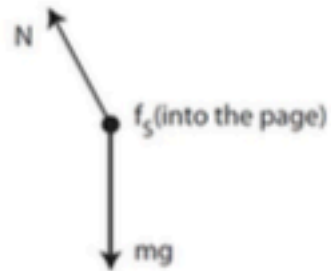
A)



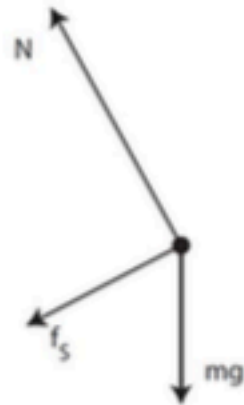
B)



C)



D)

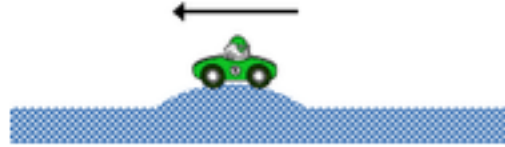


E)

Answer = E

12. A car of mass 1400 kg travelling at 15 m/s goes over a circular arc-shaped bump in the road. If the radius of the arc is 40 m, what is the normal force on the car as it is passing the top of the arc?

A) 0 N
B) 5,800 N
C) 7,900 N
D) 14,000 N
E) 22,000 N



Answer = B

- 14) Three objects are connected by massless wires over a massless frictionless pulley as shown in the figure. The tension in the wire connecting the 10.0-kg and 15.0-kg objects is measured to be 133 N. What is the tension in wire A?

A) 87.5 N
B) 245 N
C) 280 N
D) 333 N
E) 517 N

Answer: D

