6. Forces

1. A brick slides on a horizontal surface. Which of the following will increase the frictional force on it?

A) Putting a second brick on top

B) Decreasing the surface area of contact

C) Increasing the surface area of contact

D) Decreasing the mass of the brick

E) None of the above

2. The coefficient of kinetic friction:

A) is in the direction of the frictional force

B) is in the direction of the normal force

C) is the ratio of force to area

D) can have units of newtons

E) none of the above

3. When the brakes of an automobile are applied, the road exerts the greatest retarding force:

A) while the wheels are sliding

B) just before the wheels start to slide

C) when the automobile is going fastest

D) when the acceleration is least

E) at the instant when the speed begins to change

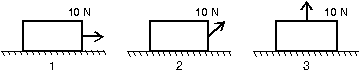
4. A forward force of 12 N is used to pull a 240-N sled at constant velocity on a frozen pond. The coefficient of friction is:

A) 0.5 B) 0.05 C) 2 D) 0.2 E) 20

5. The velocity of a 4.0-N hockey puck, sliding across a level ice surface, decreases at the rate of 0.61 m/s2. The coefficient of kinetic friction between the puck and ice is:

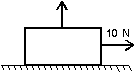
A) 0.062 B) 0.41 C) 0.62 D) 1.2 E) 9.8

6. A crate rests on a horizontal surface and a woman pulls on it with a 10-N force. No matter what the orientation of the force, the crate does not move. Rank the situations below according to the magnitude of the frictional force exerted by the surface on the crate, least to greatest.



A) 1, 2, 3 B) 2, 1, 3 C)2, 3, 1 D)1, 3, 2 E)3, 2, 1

7. A box with a weight of 50 N rests on a horizontal surface. A person pulls horizontally on it with a force of 10 N and it does not move. To start it moving, a second person pulls vertically upward on the box. If the coefficient of static friction is 0.4, what is the smallest vertical force for which the box moves?



A) 4 N B) 10 N C) 14 N D) 25 N E) 35 N

8. A 12-N horizontal force is applied to a 40-N block on a rough horizontal surface. The block is initially at rest. If *s* = 0.5 and *k* = 0.4, the frictional force on the block is:

A) 8 N B) 12 N C) 16 N D) 20 N E) 40 N

9. A 24-N horizontal force is applied to a 40-N block initially at rest on a rough horizontal surface. If *s* = 0.5 and *k* = 0.4, the frictional force on the block is:

A) 8 N B) 12 N C) 16 N D) 20 N E) 400 N

10. A horizontal shove of at least 200-N is required to start moving a 800-N crate initially at rest on a horizontal floor. The coefficient of static friction is:

A) 0.25 B) 0.125 C) 0.50 D) 4.00 E) none of these

11. A force  (larger than the largest possible force of static friction) is applied to the left to an object moving to the right on a horizontal surface. Then:

A) the object must be moving at constant speed

B) and the friction force act in opposite directions

C) the object must be slowing down

D) the object must be speeding up

E) the object must come to rest and remain at rest

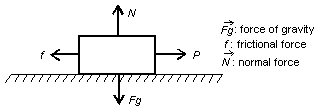
12. A block rests on a rough horizontal surface (*s* = 0.50, *k* = 0.40). A constant horizontal force, just sufficient to start the block in motion, is applied. The acceleration of the block, in m/s2, is:

A) 0 B) 0.98 C) 3.3 D) 4.5 E) 8.9

13. A car is traveling at 15 m/s on a horizontal road. The brakes are applied and the car skids to a stop in 4.0 s. The coefficient of kinetic friction between the tires and road is:

A) 0.38 B) 0.69 C) 0.76 D) 0.92 E) 1.11

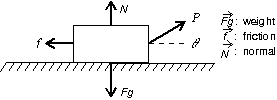
14. A boy pulls a wooden box along a rough horizontal floor at constant speed by means of a force § as shown. In the diagram *f* is the magnitude of the force of friction, *N* is the magnitude of the normal force, and *Fg* is the magnitude of the force of gravity. Which of the following must be true?



A) *P* = *f* and *N* = *Fg* B) *P* = *f* and *N* > *Fg* C) *P* > *f* and *N* < *Fg*

D) *P* > *f* and *N* = *Fg* E) none of these

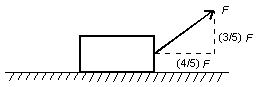
15. A boy pulls a wooden box along a rough horizontal floor at constant speed by means of a force *P* as shown. Which of the following must be true (*f* is the magnitude of the force of friction, *N* is the magnitude of the normal force, and *Fg* is the magnitude of the weight):



A) *P* = *f* and *N* = *Fg* B) *P* = *f* and *N* > *Fg* C) *P* > *f* and *N* < *Fg*

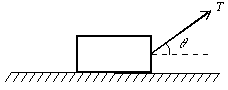
D) *P* > *f* and *N* = *Fg* E) none of these

16. A 400-N block is dragged along a rough (*uk* = 0.4) horizontal surface by an applied force as shown. The block moves at constant velocity. The magnitude of  is:



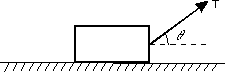
A) 100 N B) 150 N C) 200 N D) 290 N E) 400 Nb

17. A block of mass *m* is pulled along a rough horizontal floor by and applied force T as shown. The frictional force is:



A) *T* cos** B)*T* sin** C)zero D)*mg*  E)*mg* cos**

18. A block of mass *m* is pulled along a rough horizontal floor by an applied force T as shown. The vertical component of the force exerted on the block by the floor is:



A) *mg* B) *mg* – *T* cos** C) *mg* + *T* cos**

D) *mg* – *T* sin** E) *mg* + *T* sin**

19. A 12-kg crate rests on a horizontal surface and a boy pulls on it with a force that is 30 above the horizontal. If the coefficient of static friction is 0.40, the minimum magnitude force he needs to start the crate moving is:

A) 44 N B)47 N C)54 N D)56 N E)71 N

20. A crate resting on a rough horizontal floor is to be moved horizontally. The coefficient of static friction is 0.40. To start the crate moving with the weakest possible applied force, in what direction should the force be applied?

A) Horizontal

B) 24 below the horizontal C) 22 above the horizontal

D) 24 above the horizontal E) 66 below the horizontal

21. A 50-N force is applied to a crate on a horizontal rough floor, causing it to move horizontally. If the coefficient of kinetic friction is 0.50, in what direction should the force be applied to obtain the greatest acceleration?

A) Horizontal

B) 60 above the horizontal C) 30 above the horizontal

D) 27 above the horizontal E) 30 below the horizontal

22. A professor holds an eraser against a vertical chalkboard by pushing horizontally on it. He pushes with a force that is much greater than is required to hold the eraser. The force of friction exerted by the board on the eraser increases if he:

A) pushes with slightly greater force

B) pushes with slightly less force

C) stops pushing

D) raises his elbow so the force he exerts is slightly downward but has the same magnitude

E) lowers his elbow so the force he exerts is slightly upward but has the same magnitude

23. A horizontal force of 12 N pushes a 0.5-kg block against a vertical wall. The block is initially at rest. If *s* = 0.6 and *k* = 0.8 which of the following is true?

A) The frictional force is 4.9 N B) The frictional force is 7.2 N

C) The normal force is 4.9 N

D) The block will start moving and accelerate

E) If started moving downward, the block will decelerate

24. A horizontal force of 5.0 N pushes a 0.50-kg block against a vertical wall. The block is initially at rest. If *s* = 0.6 and *k* = 0.80, the frictional force is:

A) 0 B) 4.9 N C) 3.0 N D) 5.0 N E) 4.0 N

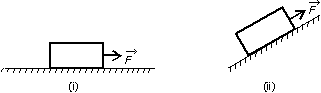
25. A horizontal force of 12 N pushes a 0.50-kg block against a vertical wall. The block is initially at rest. If *s* = 0.6 and *k* = 0.80, the acceleration of the block in m/s2 is:

A) 0 B) 9.4 C) 9.8 D) 14.4 E) 19.2

26. A horizontal force of 5.0 N pushes a 0.50-kg block against a vertical wall. The block is initially at rest. If *s* = 0.60 and *k* = 0.80, the acceleration of the block in m/s2 is:

A) 0 B) 1.8 C) 6.0 D) 8.0 E) 9.8

27. A heavy wooden block is dragged by a force  along a rough steel plate, as shown below for two possible situations. The magnitude of  is the same for the two situations. The frictional force in (ii), as compared with that in (i) is:

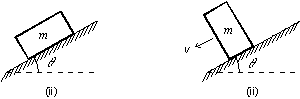


A) the same B) greater C) less

D) less for some angles and greater for others

E) can be less or greater, depending on the magnitude of the applied force.

28. A block is first placed on its long side and then on its short side on the same inclined plane. The block slides down the plane on its short side but remains at rest on its long side. A possible explanation is:



A) the short side is smoother

B) the frictional force is less because the contact area is less

C) the center of gravity is higher in the second case

D) the normal force is less in the second case

E) the force of gravity is more nearly down the plane in the second case

29. A box rests on a rough board 10 meters long. When one end of the board is slowly raised to a height of 6 meters above the other end, the box begins to slide. The coefficient of static friction is:

A) 0.8 B) 0.25 C) 0.4 D) 0.6 E) 0.75

30. A block is placed on a rough wooden plane. It is found that when the plane is tilted 30 to the horizontal, the block will slide down at constant speed. The coefficient of kinetic friction of the block with the plane is:

A) 0.500 B) 0.577 C) 1.73 D) 0.866 E) 4.90

31. A crate is sliding down an incline that is 35 above the horizontal. If the coefficient of kinetic friction is 0.40, the acceleration of the crate is:

A) 0 B)2.4 m/s2 C)5.8 m/s2 D)8.8 m/s2 E)10.3 m/s2

32. A 5.0-kg crate is resting on a horizontal plank. The coefficient of static friction is 0.50 and the coefficient of kinetic friction is 0.40. After one end of the plank is raised so the plank makes an angle of 25 with the horizontal, the force of friction is:

A) 0 B) 18 N C) 21 N D) 22 N E) 44 N

33. A 5.0-kg crate is resting on a horizontal plank. The coefficient of static friction is 0.50 and the coefficient of kinetic friction is 0.40. After one end of the plank is raised so the plank makes an angle of 30 with the horizontal, the force of friction is:

A) 0 B) 18 N C) 21 N D) 22 N E) 44 N

34. A 5.0-kg crate is on an incline that makes an angle of 30 with the horizontal. If the coefficient of static friction is 0.50, the minimum force that can be applied parallel to the plane to hold the crate at rest is:

A) 0 B) 3.3 N C) 30 N D) 46 N E) 55 N

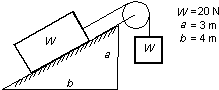
35. A 5.0-kg crate is on an incline that makes an angle 30 with the horizontal. If the coefficient of static friction is 0.5, the maximum force that can be applied parallel to the plane without moving the crate is:

A) 0 B) 3.3 N C) 30 N D) 46 N E) 55 N

36. Block A, with mass *mA*, is initially at rest on a horizontal floor. Block B, with mass *mB*, is initially at rest on the horizontal top surface of A. The coefficient of static friction between the two blocks is *s*. Block A is pulled with an increasing force. It begins to slide out from under B when its acceleration reaches:

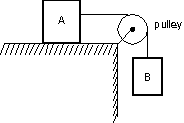
A) *g* B)*sg* C)*mBsg* D)(*mA*/*mB*)*s g* E)(*mB*/*mA*)*sg*

37. The system shown remains at rest. The force of friction on the upper block is:



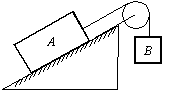
A) 4 N B) 8 N C) 12 N D) 16 N E) 20 N

38. Block A, with a mass of 50 kg, rests on a horizontal table top. The coefficient of static friction is 0.40. A horizontal string is attached to A and passes over a massless, frictionless pulley as shown. The smallest mass *mB* that will start A moving when it is attached to the other end of the string is:



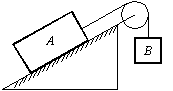
A) 20 kg B) 30 kg C) 40 kg D) 50 kg E) 70 kg

39. Block A, with a mass of 10 kg, rests on a 35 incline. The coefficient of static friction is 0.40. An attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. The smallest mass *mB*, attached to the dangling end, for which A remains at rest is:



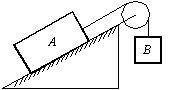
A) 2.5 kg B)3.5 kg C) 5.9 kg D) 9.0 kg E) 10.5 kg

40. Block A, with a mass of 10 kg, rests on a 35 incline. The coefficient of static friction is 0.40. An attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. The largest mass *mB*, attached to the dangling end, for which A remains at rest is:



A) 2.5 kg B)3.5 kg C)5.9 kg D)9.0 kg E)10.5 kg

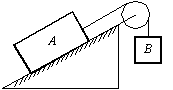
41. Block A, with a mass of 10 kg, rests on a 30 incline. The coefficient of kinetic friction is 0.20. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 8.0 kg, is attached to the dangling end of the string. The acceleration of B is:



A) 0.69 m/s2, up B) 0.69 m/s2, down C) 2.6 m/s2, up

D) 2.6 m/s2, down E) 0

42. Block A, with a mass of 10 kg, rests on a 30 incline. The coefficient of kinetic friction is 0.20. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 3.0 kg, is attached to the dangling end of the string. The acceleration of B is:



A) 0.20 m/s2, up B) 0.20 m/s2, down C) 2.8 m/s2, up

D) 2.8 m/s2, down E) 0

43. A 1000-kg airplane moves in straight flight at constant speed. The force of air friction is 1800 N. The net force on the plane is:

A) zero B) 11800 N C) 1800 N D) 9800 N

E) none of these

44. Why do raindrops fall with constant speed during the later stages of their descent?

A) The gravitational force is the same for all drops

B) Air resistance just balances the force of gravity

C) The drops all fall from the same height

D) The force of gravity is negligible for objects as small as raindrops

E) Gravity cannot increase the speed of a falling object to more than 32 ft/s

45. A ball is thrown downward from the edge of a cliff with an initial speed that is greater than the terminal speed. Initially its acceleration is

A) 0 B) upward

C) downward and greater than *g*

D) downward and less than *g*

E) downward and equal to *g*

46. A ball is thrown upward into the air with a speed that is greater than terminal speed. On the way up it slows down and, after its speed equals the terminal speed but before it gets to the top of its trajectory:

A) its speed is constant

B) it continues to slow down

C) it speeds up

D) its motion becomes jerky

E) none of the above

47. A ball is thrown upward into the air with a speed that is greater than terminal speed. It lands at the place where it was thrown. During its flight the force of air resistance is the greatest:

A) just after it is thrown B) halfway up

C) at the top of its trajectory D) halfway down

E) just before it lands

48. Uniform circular motion is the direct consequence of:

A) Newton's third law

B) centrifugal force

C) an acceleration tangent to the path

D) conservation of energy and momentum

E) an acceleration always directed toward the same point

49. An object moving in a circle at constant speed:

A) must have only one force acting on it

B) is not accelerating

C) is held to its path by centrifugal force

D) has an acceleration of constant magnitude

E) has an acceleration that is tangent to the circle

50. An object of mass *m* and another object of mass 2*m* are each forced to move along a circle of radius 1.0 m at a constant speed of 1.0 m/s. The magnitudes of their accelerations are:

A) equal B) 

C) in the ratio of 2 : 1 D) in the ratio of 4 : 1 E) zero

51. The magnitude of the force (in newtons) required to cause an 0.04-kg object to move at 0.6 m/s in a circle of radius 1.0 m is:

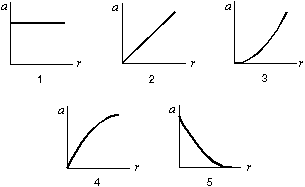
A) 2.4  10–2 B) 1.4  10–2 C) 1.4  10–2

D) 2.42  10–2 E) 3.13

52. A 0.2-kg stone is attached to a string and swung in a circle of radius 0.6 m on a horizontal and frictionless surface. If the stone makes 150 revolutions per minute, the tension force of the string is:

A) 0.03 N B)0.2 N C)0.9 N D)1.96 N E)30 N

53. Which of the following five graphs is correct for a particle moving in a circle of radius r at a constant speed of 10 m/s?



A) I B) II C) III D) IV E) V

54. An object moves in a circle. If the radius is doubled keeping the speed the same then the centripetal force must be:

A) twice as great B) half as great C) four times as great

D) one-fourth as great E) the same

55. An object moves in a circle. If the mass is tripled, the speed halved and the radius unchanged then the centripetal force must change by a factor of:

A) 3/2 B) 3/4 C) 9/4 D) 6 E) 12

56. If a satellite moves above the Earth's atmosphere in a circular orbit with constant speed, then:

A) its acceleration and velocity are in the same direction

B) the net force on it is zero C) its velocity is constant

D) it will fall back to Earth when its fuel is used up

E) its acceleration is toward the Earth

57. An 800-N passenger in a car, presses against the car door with a 200 N force when the car makes a left turn at 13 m/s. The (faulty) door will pop open under a force of 800 N. Of the following, the least speed for which the man is thrown out of the car is:

A) 14 m/s B)19 m/s C)20 m/s D) 26 m/s E) 54 m/s

58. If a certain car, going with speed *v*1, rounds a level curve with a radius *R*1, it is just on the verge of skidding. If its speed is now doubled, the radius of the tightest curve on the same road that it can round without skidding is:

A) 2*R*1 B) 4*R*1 C) *R*1/2 D) *R*1/4 E) *R*1

59. An automobile moves on a level horizontal road in a circle of radius 30 m. The coefficient of friction between tires and road is 0.50. The maximum speed with which this car can round this curve is:

A) 3.0 m/s B)4.9 m/s C)9.8 m/s D)12 m/s E)13 m/s

60. A car rounds a 75-m radius curve at a constant speed of 18 m/s. A ball is suspended by a string from the ceiling of the car and moves with the car. The angle between the string and the vertical is:

A) 0 B)1.4° C)24° D)90°

E) cannot be found without knowing the mass of the ball

61. The driver of a 1000-kg car tries to turn through a circle of radius 100 m on an unbanked curve at a speed of 10 m/s. The actual frictional force between the tires and slippery road is 900 N. The car will:

A) slide into the inside of the curve

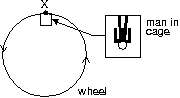
B) make the turn

C) slow down due to the frictional force

D) make the turn only if it went faster

E) slide off to the outside of the curve

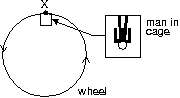
62. A giant wheel, having a diameter of 40 m, is fitted with a cage and platform on which a man of mass *m* stands. The wheel is rotated in a vertical plane at such a speed that the force exerted by the man on the platform is equal to his weight when the cage is at X, as shown. The net force on the man at point X is:



A) zero B) *mg*, down C) *mg*, up

D) 2 *mg*, down E) 2 *mg*, up

63. A giant wheel, 40 m in diameter, is fitted with a cage and platform on which a man can stand. The wheel rotates at such a speed that when the cage is at X (as shown) the force exerted by the man on the platform is equal to his weight. The speed of the man (in m/s) is:



A) 14 B) 20 C) 28 D) 80 E) 120

64. A person riding a Ferris wheel is strapped into her seat by a seat belt. The wheel is spun so that the centripetal acceleration is *g*. Select the correct combination of forces that act on her when she is at the top. In the table, *Fg* = force of gravity, down; *Fb* = seat belt force, down; and *Fs* = seat force, up.

A) *Fg* = 0, *Fb* = mg, *Fs* = 0 B) *Fg* = mg, *Fb* = 0, *Fs* = 0

C) *Fg* = 0, *Fb* = 0, *Fs* = mg D) *Fg* = mg, *Fb* = mg, *Fs* = 0

E) *Fg* = mg, *Fb* = 0, *Fs* = mg

65. One end of a 1.0-m long string is fixed, the other end is attached to a 2.0-kg stone. The stone swings in a vertical circle, passing the bottom point at 4.0 m/s. The tension force of the string (in newtons) at this point is about:

A) 0 B) 12 C) 20 D) 32 E) 52

66. One end of a 1.0-m string is fixed, the other end is attached to a 2.0-kg stone. The stone swings in a vertical circle, passing the top point at 4.0 m/s. The tension force of the string (in newtons) at this point is about:

A) 0 B) 12 C) 20 D) 32 E) 52

67. A coin is placed on a horizontal phonograph turntable. Let *N* be the normal force exerted by the turntable on the coin, *f* be the frictional force exerted by the turntable on the coin, and *f*s, max be the maximum force of the static friction. The speed of the turntable is increased in small steps. If the coin does not slide, then

A) *N* increases, *f* increases, and *f*s, max stays the same

B) *N* increases, *f* increases, and *f*s, max increases

C) *f* increases and both *N* and *f*s, max stay the same

D) *N*, *f*, and *f*s, max all stay the same

E) *N*, *f*, and *f*s, max all increase

68. The iron ball shown is being swung in a vertical circle at the end of a 0.7-m string. How slowly, in ft/s, can the ball go through its top position without having the string go slack?



A) 1.3 m/s B)2.6 m/s C)3.9 m/s D)6.9 m/s E)9.8 m/s

69. On some roller coasters each car is suspended below the track by means of a rod that is free to swivel in any direction. When such a car rounds a 45-m radius horizontal curve at 22 m/s (about 50 mph), what angle does the rod make with the vertical?

A) 0

B) 25

C) 42

D) 65

E) 90

70. Circular freeway entrance and exit ramps are commonly banked to handle a car moving at 13 m/s. To design a similar ramp for 26 m/s one should:

A) increase radius by factor of 2

B) decrease radius by factor of 2

C) increase radius by factor of 4

D) decrease radius by factor of 4

E) 

71. At what angle should the roadway on a curve with a 50m radius be banked to allow cars to negotiate the curve at 12 m/s even if the roadway is icy (and the frictional force is zero)?

A) 0

B) 16°

C) 18°

D) 35°

E) 73°