2007-2011 PHYSICAL SETTING PHYSICS Supplements

MECHANICS

TOPIC A: *Measurement*

❷ PART 2: Approximating Mass and Dimension

1) What is the approximate length of a baseball bat?
   A) 100 m
   B) 10^{-1} m
   C) 10^{1} m
   D) 10^{2} m

2) What is the approximate diameter of an inflated basketball?
   A) 2×10^{-1} m
   B) 2×10^{-2} m
   C) 2×10^{0} m
   D) 2×10^{1} m

3) The mass of a paper clip is approximately
   A) 1×10^{-3} kg
   B) 1×10^{6} kg
   C) 1×10^{3} kg
   D) 1×10^{-6} kg

4) The weight of a chicken egg is most nearly equal to
   A) 10^{0} N
   B) 10^{-3} N
   C) 10^{-2} N
   D) 10^{2} N

❸ PART 3: Scalar and Vector Quantities

5) Scalar is to vector as
   A) speed is to velocity
   B) displacement is to distance
   C) displacement is to velocity
   D) speed is to distance

6) Which of the following is a vector quantity?
   A) displacement
   B) speed
   C) work
   D) mass

7) Which of the following is a vector quantity?
   A) electric field strength
   B) electric charge
   C) electric potential difference
   D) electric resistance

8) Which of the following quantities is a vector?
   A) impulse
   B) power
   C) speed
   D) time

9) Which of the following is *not* a vector quantity?
   A) electric charge
   B) magnetic field strength
   C) velocity
   D) displacement

10) The speedometer in a car does *not* measure the car's velocity because velocity is a
   A) vector quantity and has a direction associated with it
   B) vector quantity and does not have a direction associated with it
   C) scalar quantity and has a direction associated with it
   D) scalar quantity and does not have a direction associated with it

❹ PART 4: Distance and Displacement

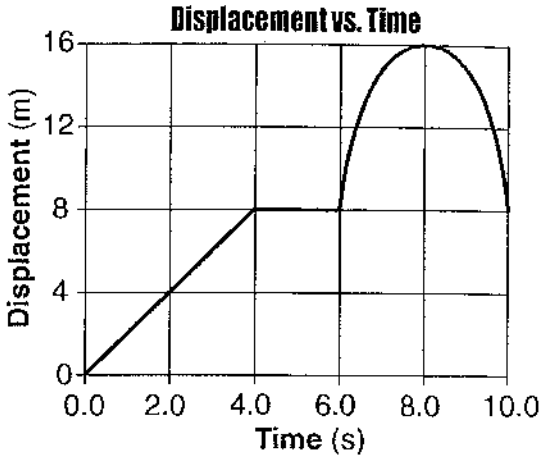
11) A baseball player runs 27.4 meters from the batter's box to first base, overruns first base by 3.0 meters, and then returns to first base. Compared to the total distance traveled by the player, the magnitude of the player's total displacement from the batter's box is

A) 6.0 m shorter
B) 3.0 m shorter
C) 3.0 m longer
D) 6.0 m longer

12) A child walks 5.0 meters north, then 4.0 meters east, and finally 2.0 meters south. What is the magnitude of the resultant displacement of the child after the entire walk?

A) 5.0 m
B) 1.0 m
C) 3.0 m
D) 11.0 m

13) The graph below represents the displacement of an object moving in a straight line as a function of time.



What was the total distance traveled by the object during the 10.0-second time interval?

A) 24 m
B) 0 m
C) 8 m
D) 16 m

TOPIC B: *Kinematics*

❶ PART 1: Simple Motion

14) On a highway, a car is driven 80. kilometers during the first 1.00 hour of travel, 50. kilometers during the next 0.50 hour, and 40. kilometers in the final 0.50 hour. What is the car's average speed for the entire trip?

A) 85 km/h
B) 45 km/h
C) 60. km/h
D) 170 km/h

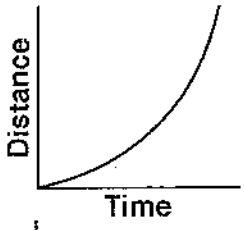
15) A high-speed train in Japan travels a distance of 300. kilometers in 3.60×10^3 seconds. What is the average speed of this train?

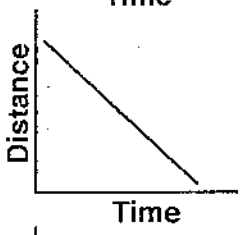
A) 83.3 m/s
B) 1.20×10^{-2} m/s
C) 8.33×10^{-2} m/s
D) 12.0 m/s

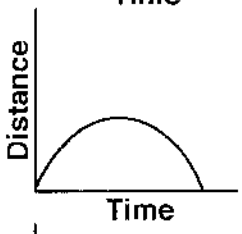
❷ PART 2: ACCELERATED MOTION

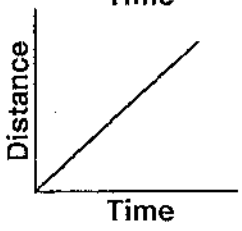
♦ ACCELERATION

16) A cart travels with a constant nonzero acceleration along a straight line. Which of the following graphs *best* represents the relationship between the distance the cart travels and time of travel?

A) 

B) 

C) 

D) 

17) As a car is driven south in a straight line with decreasing speed, the acceleration of the car must be
A) directed northward
B) directed southward
C) zero
D) constant, but not zero

18) An object accelerates uniformly from 3.0 meters per second east to 8.0 meters per second east in 2.0 seconds. What is the magnitude of the acceleration of the object?
A) 2.5 m/s^2 C) 5.5 m/s^2
B) 5.0 m/s^2 D) 11 m/s^2

19) A car increases its speed from 9.6 meters per second to 11.2 meters per second in 4.0 seconds. The average acceleration of the car during this 4.0-second interval is
A) 0.40 m/s^2 C) 2.8 m/s^2
B) 2.4 m/s^2 D) 5.2 m/s^2

20) If a car accelerates uniformly from rest to 15 meters per second over a distance of 100. meters, the magnitude of the car's acceleration is
A) 1.1 m/s^2 C) 2.3 m/s^2
B) 0.15 m/s^2 D) 6.7 m/s^2

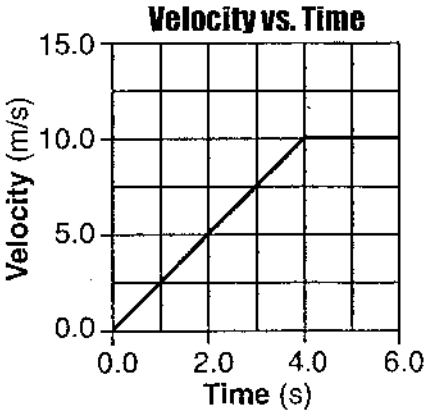
21) An observer recorded the following data for the motion of a car undergoing constant acceleration.

Time (s)	Speed (m/s)
3.0	4.0
5.0	7.0
6.0	8.5

What was the magnitude of the acceleration of the car?
A) 1.5 m/s^2 C) 2.0 m/s^2
B) 1.3 m/s^2 D) 4.5 m/s^2

22) A race car starting from rest accelerates uniformly at a rate of 4.90 meters per second^2. What is the car's speed after it has traveled 200. meters?
A) 44.3 m/s C) 62.6 m/s
B) 1,960 m/s D) 31.3 m/s

23) The graph below represents the motion of a car during a 6.0-second time interval.



Based on the graph shown, what is the acceleration of the car at $t = 5.0$ seconds?
A) 0.0 m/s^2 C) 2.5 m/s^2
B) 2.0 m/s^2 D) 10. m/s^2

◆ Distance Traveled by an Accelerating Body

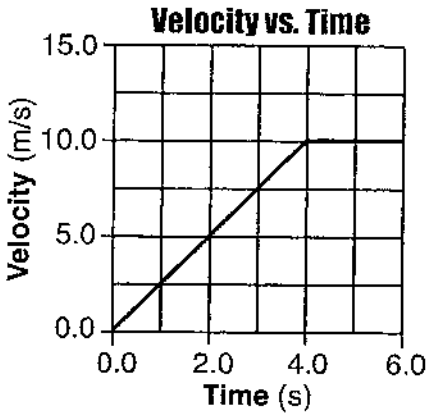
24) The speed of an object undergoing constant acceleration increases from 8.0 meters per second to 16.0 meters per second in 10. seconds. How far does the object travel during the 10. seconds?

A) 1.2×10^2 m
B) 3.6×10^2 m
C) 1.6×10^2 m
D) 8.0×10^1 m

25) A car traveling on a straight road at 15.0 meters per second accelerates uniformly to a speed of 21.0 meters per second in 12.0 seconds. The total distance traveled by the car in this 12.0-second time interval is

A) 216 m
B) 36.0 m
C) 180. m
D) 252 m

26) The graph below represents the motion of a car during a 6.0-second time interval.



Based on the given data, what is the total distance traveled by the given car during this 6.0-second interval?

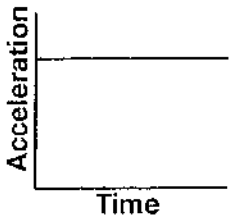
A) 40. m
B) 10. m
C) 20. m
D) 60. m

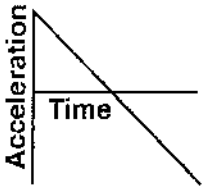
27) A child, starting from rest at the top of a playground slide, reaches a speed of 7.0 meters per second at the bottom of the slide. What is the vertical height of the slide? [*Neglect friction.*]

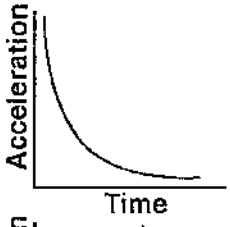
A) 2.5 m
B) 0.71 m
C) 1.4 m
D) 3.5 m

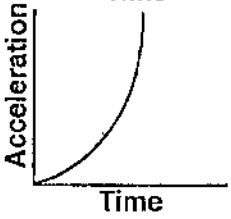
♦ Freely Falling Bodies

28) Which of the following graphs *best* represents the relationship between the acceleration of an object falling freely near the surface of Earth and the time that it falls?

A) 

B) 

C) 

D) 

29) A rock is dropped from a bridge. What happens to the magnitude of the acceleration and the speed of the rock as it falls? [*Neglect friction.*]

A) Acceleration remains the same and speed increases.
B) Both acceleration and speed increase.
C) Both acceleration and speed remain the same.
D) Acceleration increases and speed decreases.

30) A book of mass m falls freely from rest to the floor from the top of a desk of height h. What is the speed of the book upon striking the floor?

A) $\sqrt{2gh}$ C) mgh
B) $2gh$ D) mh

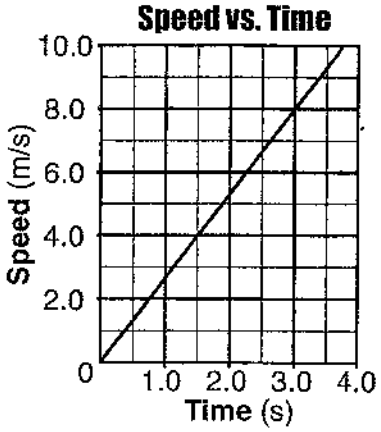
31) A ball is thrown straight downward with a speed of 0.50 meter per second from a height of 4.0 meters. What is the speed of the ball 0.70 second after it is released? [*Neglect friction.*]

A) 7.4 m/s C) 9.8 m/s
B) 0.50 m/s D) 15 m/s

32) What is the speed of a 2.5-kilogram mass after it has fallen freely from rest through a distance of 12 meters?

A) 15 m/s C) 30. m/s
B) 4.8 m/s D) 43 m/s

33) The graph below shows the relationship between the speed and elapsed time for an object falling freely from rest near the surface of a planet.



What is the total distance the object falls during the first 3.0 seconds?

A) 12 m C) 44 m
B) 24 m D) 72 m

34) A 25-newton weight falls freely from rest from the roof of a building. What is the total distance the weight falls in the first 1.0 second?

A) 4.9 m C) 9.8 m
B) 19.6 m D) 2.5 m

35) A baseball dropped from the roof of a tall building takes 3.1 seconds to hit the ground. How tall is the building? [*Neglect friction.*]

A) 47 m C) 30. m
B) 15 m D) 94 m

36) An astronaut standing on a platform on the Moon drops a hammer. If the hammer falls 6.0 meters vertically in 2.7 seconds, what is its acceleration?

A) 1.6 m/s^2 C) 4.4 m/s^2
B) 2.2 m/s^2 D) 9.8 m/s^2

37) A rock falls from rest a vertical distance of 0.72 meter to the surface of a planet in 0.63 second. What is the magnitude of the acceleration due to gravity on the planet?

A) 3.6 m/s^2 C) 1.1 m/s^2
B) 2.3 m/s^2 D) 9.8 m/s^2

38) A 5.0-kilogram sphere, starting from rest, falls freely 22 meters in 3.0 seconds near the surface of a planet. Compared to the acceleration due to gravity near Earth's surface, the acceleration due to gravity near the surface of the planet is approximately

A) one-half as great
B) the same
C) twice as great
D) four times as great

PART 3: PROJECTILES AND TRAJECTORIES

39) Two stones, *A* and *B*, are thrown horizontally from the top of a cliff. Stone *A* has an initial speed of 15 meters per second and stone *B* has an initial speed of 30. meters per second. Compared to the time it takes stone *A* to reach the ground, the time it takes stone *B* to reach the ground is

A) the same
B) twice as great
C) half as great
D) four times as great

40) A projectile launched at an angle of 45° above the horizontal travels through the air. Compared to the projectile's theoretical path with no air friction, the actual trajectory of the projectile with air friction is

A) lower and shorter
B) lower and longer
C) higher and shorter
D) higher and longer

41) A machine launches a tennis ball at an angle of 25° above the horizontal at a speed of 14 meters per second. The ball returns to level ground. Which combination of changes must produce an increase in time of flight of a second launch?

A) increase the launch angle and increase the ball's initial speed
B) decrease the launch angle and decrease the ball's initial speed
C) decrease the launch angle and increase the ball's initial speed
D) increase the launch angle and decrease the ball's initial speed

42) A golf ball is given an initial speed of 20. meters per second and returns to level ground. What launch angle above level ground results in the ball traveling the *greatest* horizontal distance? [*Neglect friction.*]

A) 45° C) 30.°
B) 60.° D) 15°

43) A soccer ball kicked on a level field has an initial vertical velocity component of 15.0 meters per second. Assuming the ball lands at the same height from which it was kicked, what is the total time the ball is in the air? [*Neglect friction.*]

A) 3.06 s C) 1.53 s
B) 0.654 s D) 6.12 s

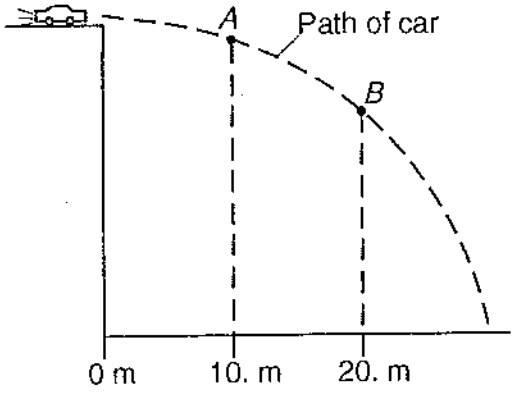
44) Two spheres, *A* and *B*, are simultaneously projected horizontally from the top of a tower. Sphere *A* has a horizontal speed of 40. meters per second and sphere *B* has a horizontal speed of 20. meters per second. Which statement *best* describes the time required for the spheres to reach the ground and the horizontal distance they travel? [*Neglect friction and assume the ground is level.*]

A) Both spheres hit the ground at the same time, but sphere *A* lands twice as far as sphere *B* from the base of the tower.
B) Both spheres hit the ground at the same time and at the same distance from the base of the tower.
C) Both spheres hit the ground at the same time, but sphere *B* lands twice as far as sphere *A* from the base of the tower.
D) Sphere *A* hits the ground before sphere *B*, and sphere *A* lands twice as far as sphere *B* from the base of the tower.

45) A plane flying horizontally above Earth's surface at 100. meters per second drops a crate. The crate strikes the ground 30.0 seconds later. What is the magnitude of the horizontal component of the crate's velocity just before it strikes the ground? [*Neglect friction.*]

A) 100. m/s
B) 0 m/s
C) 294 m/s
D) 394 m/s

46) The diagram below represents the path of a stunt car that is driven off a cliff, neglecting friction.



Compared to the horizontal component of the car's velocity at point *A*, the horizontal component of the car's velocity at point *B* is

A) the same
B) smaller
C) greater

47) Four projectiles, *A*, *B*, *C*, and *D*, were launched from, and returned to, level ground. The data table below shows the initial horizontal speed, initial vertical speed, and time of flight for each projectile.

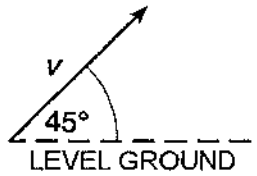
DATA TABLE

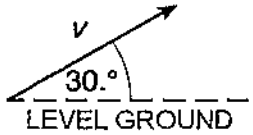
Projectile	Initial Horizontal Speed (m/s)	Initial Vertical Speed (m/s)	Time of Flight (s)
A	40.0	29.4	6.00
B	60.0	19.6	4.00
C	50.0	24.5	5.00
D	80.0	19.6	4.00

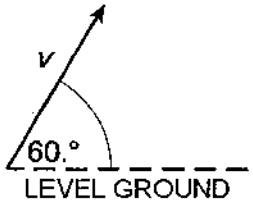
Which projectile traveled the *greatest* horizontal distance? [*Neglect friction.*]

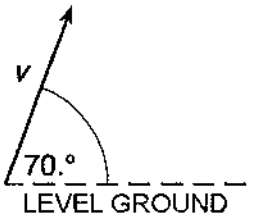
A) *A*
B) *B*
C) *C*
D) *D*

48) Four identical projectiles are launched with the same initial speed, v, but at various angles above the level ground. Which one of the following diagrams represents the initial velocity of the projectile that will have the *largest* total horizontal displacement? [*Neglect air resistance.*]

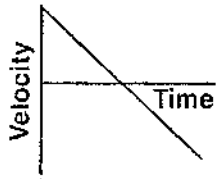
A) 

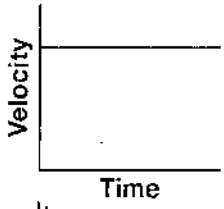
B) 

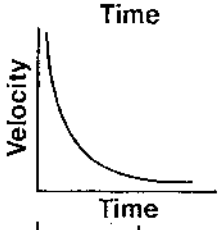
C) 

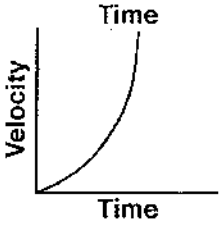
D) 

49) Which of the following graphs *best* represents the relationship between the velocity of an object thrown straight upward from Earth's surface and the time that elapses while it is in the air? [*Neglect friction.*]

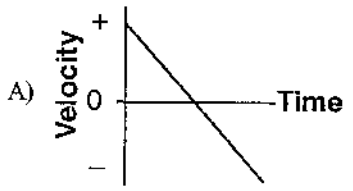
A) 

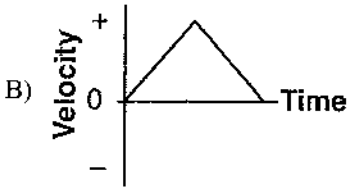
B) 

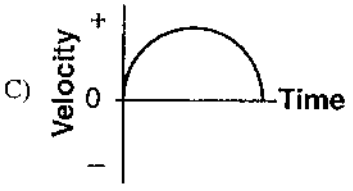
C) 

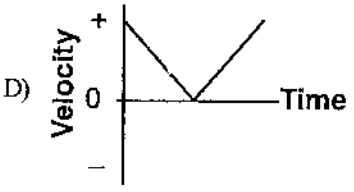
D) 

50) A student throws a baseball vertically upward and then catches it. If vertically upward is considered to be the positive direction, which graph *best* represents the relationship between velocity and time for the baseball? [*Neglect friction.*]

A) 

B) 

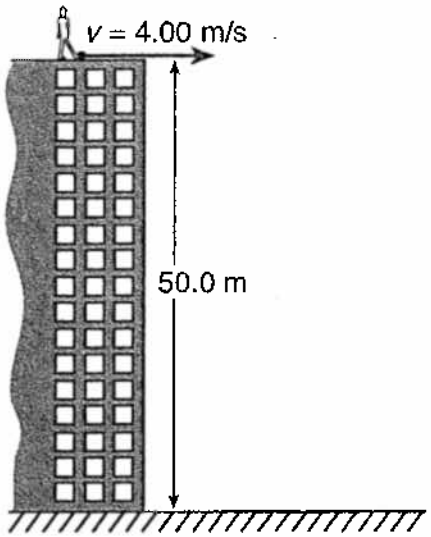
C) 

D) 

51) A ball is thrown vertically upward with an initial velocity of 29.4 meters per second. What is the maximum height reached by the ball? [*Neglect friction.*]

A) 44.1 m
B) 14.7 m
C) 29.4 m
D) 88.1 m

52) As shown in the diagram below, a student standing on the roof of a 50.0-meter-high building kicks a stone at a horizontal speed of 4.00 meters per second.



How much time is required for the stone to reach the level ground below? [*Neglect friction.*]

A) 3.19 s
B) 5.10 s
C) 10.2 s
D) 12.5 s

TOPIC C: *Net Force and Equilibrium*

PART 1: Vector Components of a Net Force

53) A force of one newton is equivalent to one

A) $\frac{kg \cdot m}{s^2}$
B) $\frac{kg \cdot m}{s}$
C) $\frac{kg \cdot m^2}{s^2}$
D) $\frac{kg^2 \cdot m^2}{s^2}$

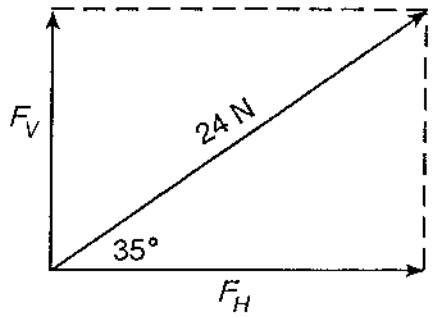
54) A 6.0-newton force and an 8.0-newton force act concurrently on a point. As the angle between these forces increases from 0° to 90°, the magnitude of their resultant

A) decreases
B) increases
C) remains the same

55) Two forces act concurrently on an object. Their resultant force has the *largest* magnitude when the angle between the forces is

A) 0° C) 90°
B) 30° D) 180°

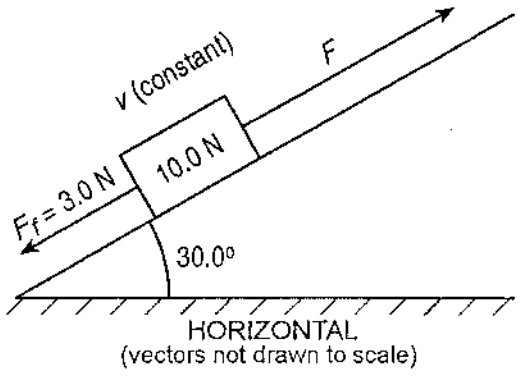
56) The vector diagram below represents the horizontal component, F_H, and the vertical component, F_V, of a 24-newton force acting at 35° above the horizontal.



What are the magnitudes of the horizontal and vertical components?

A) F_H = 20. N and F_V = 14 N
B) F_H = 3.5 N and F_V = 4.9 N
C) F_H = 4.9 N and F_V = 3.5 N
D) F_H = 14 N and F_V = 20. N

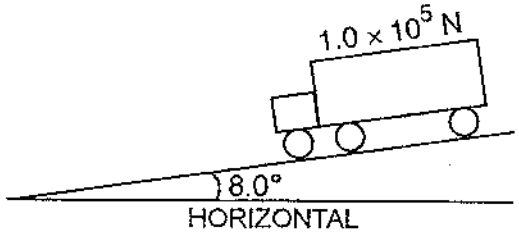
57) A block weighing 10.0 newtons is on a ramp inclined at 30.0° to the horizontal. A 3.0-newton force of friction, F_f, acts on the block as it is pulled up the ramp at constant velocity with force F, which is parallel to the ramp, as shown in the diagram below.



What is the magnitude of force F?

A) 8.0 N C) 10. N
B) 7.0 N D) 13 N

58) The diagram below shows a 1.0×10^5-newton truck at rest on a hill that makes an angle of 8.0° with the horizontal.



What is the component of the truck's weight parallel to the hill?

A) 1.4×10^4 N C) 1.0×10^4 N
B) 1.4×10^3 N D) 9.9×10^4 N

59) A soccer player kicks a ball with an initial velocity of 10. meters per second at an angle of 30.° above the horizontal. What is the magnitude of the horizontal component of the ball's initial velocity?

A) 8.7 m/s C) 9.8 m/s
B) 5.0 m/s D) 10. m/s

60) An airplane flies with a velocity of 750. kilometers per hour, 30.0° south of east. What is the magnitude of the eastward component of the plane's velocity?

A) 650. km/h C) 433 km/h
B) 866 km/h D) 375 km/h

61) A motorboat, which has a speed of 5.0 meters per second in still water, is headed east as it crosses a river flowing south at 3.3 meters per second. What is the magnitude of the boat's resultant velocity with respect to the starting point?

A) 6.0 m/s C) 5.0 m/s
B) 3.3 m/s D) 8.3 m/s

Questions 62 and 63 refer to the following:

A stream is 30. meters wide and its current flows southward at 1.5 meters per second. A toy boat is launched with a velocity of 2.0 meters per second eastward from the west bank of the stream.

62) Based on the given information, what is the magnitude of the toy boat's resultant velocity as it crosses the stream?

A) 2.5 m/s C) 3.0 m/s
B) 0.5 m/s D) 3.5 m/s

63) Based on the given information, how much time is required for the toy boat to reach the opposite bank of the stream?

A) 15 s C) 12 s
B) 8.6 s D) 60. s

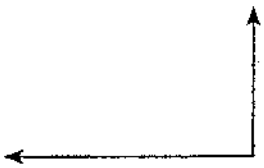
❷ PART 2: EQUILIBRIUM

64) Which of the following bodies is in equilibrium?
- A) a car moving with a constant speed along a straight, level road
- B) a satellite orbiting Earth in a circular orbit
- C) a ball falling freely toward the surface of Earth
- D) a projectile at the highest point in its trajectory

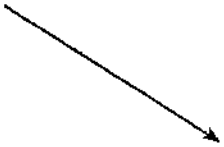
65) Which one of the following bodies is in equilibrium?
- A) a block sliding at constant velocity across a tabletop
- B) a satellite moving around Earth in a circular orbit
- C) a cart rolling down a frictionless incline
- D) an apple falling freely toward the surface of Earth

66) As the angle between two concurrent forces decreases, the magnitude of the force required to produce equilibrium
- A) increases
- B) decreases
- C) remains the same

67) The diagram below represents two concurrent forces.



Which vector represents the force that will produce equilibrium with these two forces?

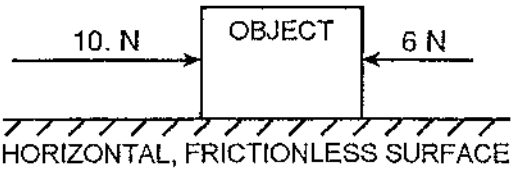
A)


B)


C)

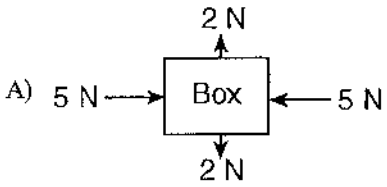

D)

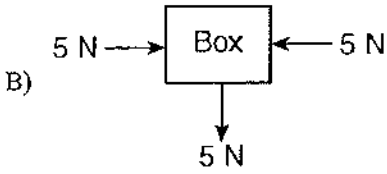
68) Two forces act concurrently on an object on a horizontal, frictionless surface, as shown in the diagram below.

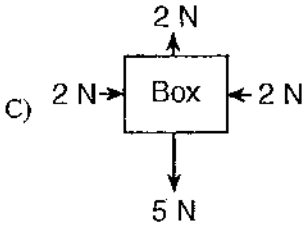


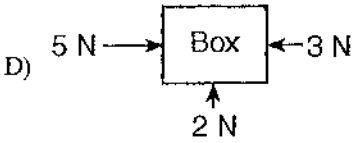
What additional force, when applied to the object, will establish equilibrium?
- A) 4 N toward the left
- B) 16 N toward the right
- C) 16 N toward the left
- D) 4 N toward the right

69) Which diagram represents a box in equilibrium?

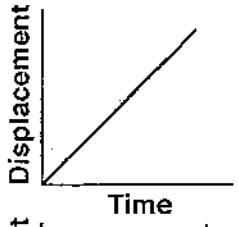
A)


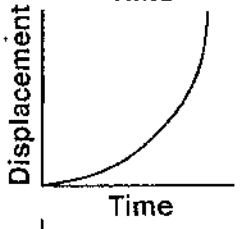
B)


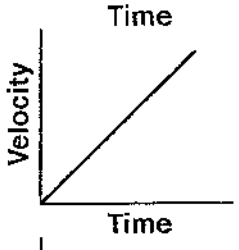
C)


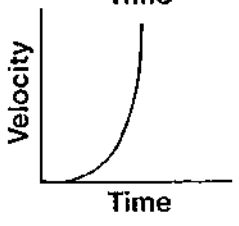
D)


70) Which of the following graphs *best* represents the motion of an object in equilibrium?

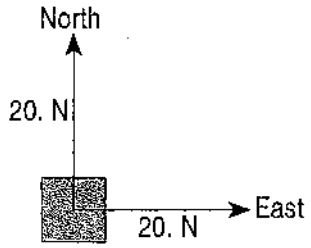
A) 

B) 

C) 

D) 

71) In the diagram below, a 20.-newton force due north and a 20.-newton force due east act concurrently on an object, as shown in the diagram below.



What additional force is necessary to bring the object into a state of equilibrium?

A) 28 N, southwest
B) 20. N, northeast
C) 20. N, southwest
D) 28 N, northeast

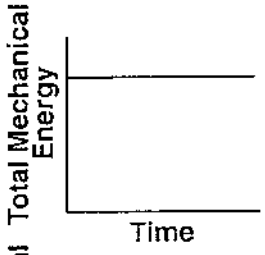
72) A force of 25 newtons east and a force of 25 newtons west act concurrently on a 5.0-kilogram cart. What is the acceleration of the cart?

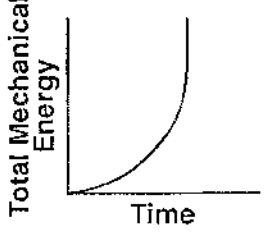
A) 0 m/s^2
B) 1.0 m/s^2 west
C) 0.20 m/s^2 east
D) 5.0 m/s^2 east

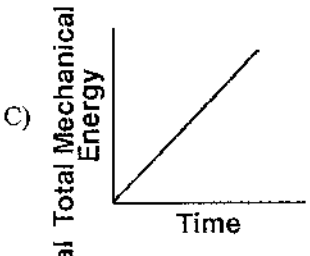
TOPIC D: *Static and Dynamic Systems*

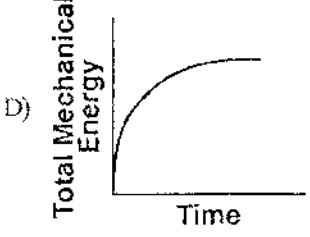
PART 1: Forces in a Static System

73) A wooden crate is pushed at constant speed across a level wooden floor. Which of the following graphs *best* represents the relationship between the total mechanical energy of the crate and the duration of time the crate is pushed?

A) 

B) 

C) 

D) 

74) What is the magnitude of the force needed to keep a 60.-newton rubber block moving across level, dry asphalt in a straight line at a constant speed of 2.0 meters per second?

A) 40. N
B) 51 N
C) 60. N
D) 120 N

75) An 80-kilogram skier slides on waxed skis along a horizontal surface of snow at constant velocity while pushing with his poles. What is the horizontal component of the force pushing him forward?

A) 40 N
B) 0.05 N
C) 0.4 N
D) 4 N

76) A 70.-kilogram cyclist develops 210 watts of power while pedaling at a constant velocity of 7.0 meters per second east. What average force is exerted eastward on the bicycle to maintain this constant speed?

A) 30. N
B) 490 N
C) 3.0 N
D) 0 N

❷ PART 2: FORCES IN A DYNAMIC SYSTEM

◆ FORCE OF FRICTION

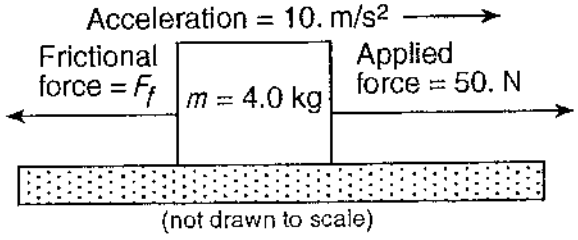
77) A car's performance is tested on various horizontal road surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the *greatest* force of friction to stop the car on

A) dry concrete
B) dry asphalt
C) wet concrete
D) wet asphalt

78) Which of the following statemens *best* explains why a "wet saw" used to cut through fine optical crystals is constantly lubricated with oil?

A) Lubrication decreases friction and minimizes the increase of internal energy.
B) Lubrication decreases friction and maximizes the increase of internal energy.
C) Lubrication increases friction and minimizes the increase of internal energy.
D) Lubrication increases friction and maximizes the increase of internal energy.

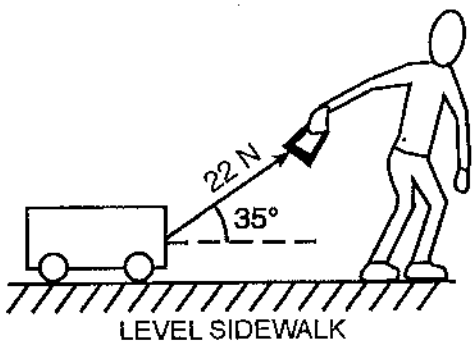
79) The diagram below shows a 4.0-kilogram object accelerating at 10. meters per second^2 on a rough horizontal surface.



What is the magnitude of the frictional force F_f acting on the object?

A) 10. N
B) 5.0 N
C) 20. N
D) 40. N

80) A child pulls a wagon at a constant velocity along a level sidewalk. The child does this by applying a 22-newton force to the wagon handle, which is inclined at 35° to the sidewalk as shown below.



What is the magnitude of the force of friction on the wagon?

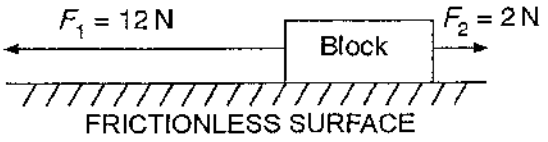
A) 18 N
B) 11 N
C) 13 N
D) 22 N

♦ Mass and Acceleration ($F = ma$)

81) A student is standing in an elevator that is accelerating downward. The force that the student exerts on the floor of the elevator must be

A) less than the weight of the student when at rest
B) greater than the weight of the student when at rest
C) less than the force of the floor on the student
D) greater than the force of the floor on the student

82) Two forces, F_1 and F_2, are applied to a block on a frictionless, horizontal surface as shown below.



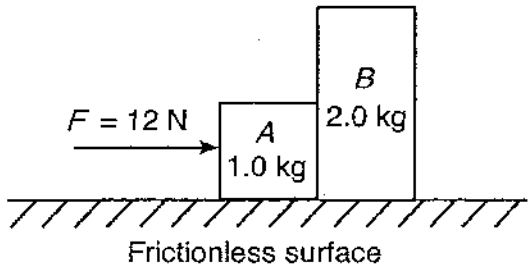
If the magnitude of the block's acceleration is 2.0 meters per second^2, what is the mass of the block?

A) 5 kg
B) 1 kg
C) 6 kg
D) 7 kg

83) A 25-newton horizontal force northward and a 35-newton horizontal force southward act concurrently on a 15-kilogram object on a frictionless surface. What is the magnitude of the object's acceleration?

A) 0.67 m/s^2
B) 1.7 m/s^2
C) 2.3 m/s^2
D) 4.0 m/s^2

84) The diagram below shows a horizontal 12-newton force being applied to two blocks, A and B, initially at rest on a horizontal, frictionless surface. Block A has a mass of 1.0 kilogram and block B has a mass of 2.0 kilograms.



The magnitude of the acceleration of block B is

A) 4.0 m/s^2
B) 6.0 m/s^2
C) 2.0 m/s^2
D) 3.0 m/s^2

85) A 1,200-kilogram space vehicle travels at 4.8 meters per second along the level surface of Mars. If the magnitude of the gravitational field strength on the surface of Mars is 3.7 newtons per kilogram, what is the magnitude of the normal force acting on the vehicle?

A) 4,400 N
B) 320 N
C) 930 N
D) 5,800 N

♦ Equal and Opposite Forces

86) A carpenter hits a nail with a hammer. Compared to the magnitude of the force the hammer exerts on the nail, the magnitude of the force the nail exerts on the hammer during contact is

A) the same
B) less
C) greater

87) If a 65-kilogram astronaut exerts a force with a magnitude of 50. newtons on a satellite that she is repairing, what is the magnitude of the force that the satellite exerts on her?

A) 50. N
B) 0 N
C) 50. N less than her weight
D) 50. N more than her weight

88) A student pulls a 60.-newton sled with a force having a magnitude of 20. newtons. What is the magnitude of the force that the sled exerts on the student?

A) 20. N
B) 40. N
C) 60. N
D) 80. N

89) A 0.149-kilogram baseball, initially moving at 15 meters per second, is brought to rest in 0.040 second by a baseball glove on a catcher's hand. The magnitude of the average force exerted on the ball by the glove is

A) 56 N
B) 2.2 N
C) 2.9 N
D) 17 N

90) A 0.15-kilogram baseball moving at 20. meters per second is stopped by a catcher in 0.010 second. What is the average force stopping the ball?

A) 3.0×10^2 N
B) 3.0×10^{-2} N
C) 3.0×10^0 N
D) 3.0×10^1 N

91) A motorcycle being driven on a dirt path hits a rock. Its 60.-kilogram cyclist is projected over the handlebars at 20. meters per second into a haystack. If the cyclist is brought to rest in 0.50 second, the magnitude of the average force exerted on the cyclist by the haystack is

A) 2.4×10^3 N
B) 6.0×10^1 N
C) 5.9×10^2 N
D) 1.2×10^3 N

92) A bicycle and its rider have a combined mass of 80. kilograms and a speed of 6.0 meters per second. What is the magnitude of the average force needed to bring the bicycle and its rider to a stop in 4.0 seconds?

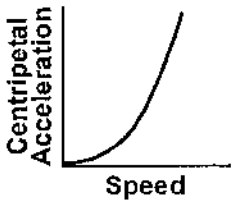
A) 1.2×10^2 N
B) 3.2×10^2 N
C) 4.8×10^2 N
D) 1.9×10^3 N

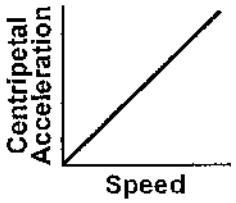
93) A 75-kilogram hockey player is skating across the ice at a speed of 6.0 meters per second. What is the magnitude of the average force required to stop the player in 0.65 second?

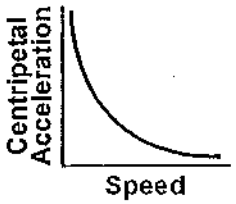
A) 690 N
B) 120 N
C) 290 N
D) 920 N

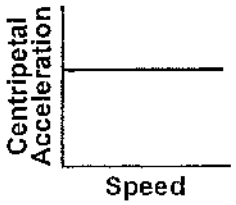
PART 3: Uniform Circular Motion

94) Which graph *best* represents the relationship between the magnitude of the centripetal acceleration and the speed of an object moving in a circle of constant radius?

A)


B)


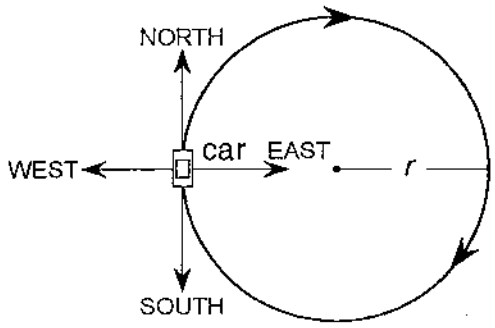
C)


D)


95) A 0.50-kilogram object moves in a horizontal circular path with a radius of 0.25 meter at a constant speed of 4.0 meters per second. What is the magnitude of the object's acceleration?

A) 64 m/s^2
B) 8.0 m/s^2
C) 16 m/s^2
D) 32 m/s^2

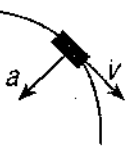
96) A car moves with a constant speed in a clockwise direction around a circular path of radius r, as represented in the diagram below.

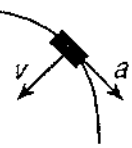


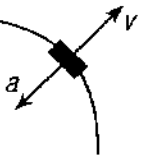
When the car is in the position shown, its acceleration is directed toward what direction?

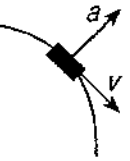
A) east
B) north
C) west
D) south

97) A car rounds a horizontal curve of constant radius at a constant speed. Which diagram *best* represents the directions of *both* the car's velocity, v, and acceleration, a?

A) 

B) 

C) 

D) 

98) The centripetal force acting on the space shuttle as it orbits Earth is equal to the shuttle's

A) weight
B) inertia
C) momentum
D) velocity

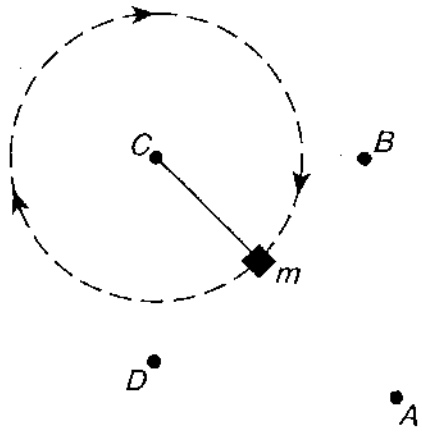
99) Centripetal force F_c acts on a car going around a curve. If the speed of the car were twice as great, the magnitude of the centripetal force necessary to keep the car moving in the same path would be

A) $4F_c$
B) F_c
C) $2F_c$
D) $\frac{F_c}{2}$

100) A 1,750-kilogram car travels at a constant speed of 15.0 meters per second around a horizontal, circular track with a radius of 45.0 meters. What is the magnitude of the centripetal force acting on the car?

A) 8,750 N
B) 5.00 N
C) 583 N
D) 3.94×10^5 N

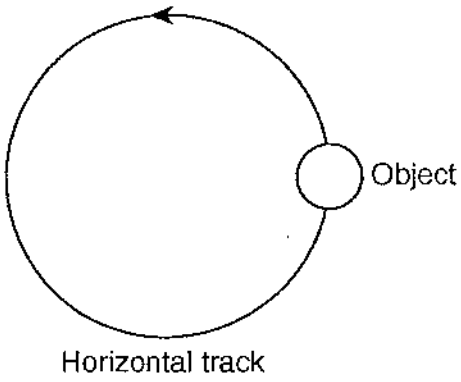
101) The diagram below represents a mass, m, being swung clockwise at constant speed in a horizontal circle.



At the instant shown, the centripetal force acting on mass m is directed toward point

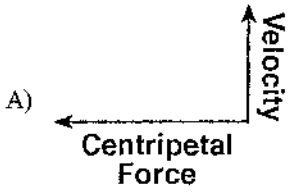
A) *A*
B) *B*
C) *C*
D) *D*

102) The diagram below shows an object moving counterclockwise around a horizontal, circular track.

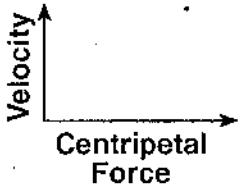


Which diagram represents the direction of *both* the object's velocity and the centripetal force acting on the object when it is in the position shown?

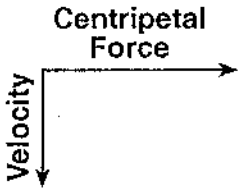
A)



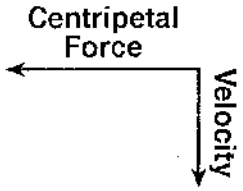
B)



C)



D)



103) The magnitude of the centripetal force acting on an object traveling in a horizontal, circular path will decrease if the

A) radius of the path is increased
B) mass of the object is increased
C) direction of motion of the object is reversed
D) speed of the object is increased

Questions 104 and 105 refer to the following:

A go-cart travels around a flat, horizontal, circular track with a radius of 25 meters. The mass of the go-cart with the rider is 200. kilograms. The magnitude of the maximum centripetal force exerted by the track on the go-cart is 1,200. newtons.

104) What is the maximum speed the 200.-kilogram go-cart described can travel without sliding off the track?

A) 12 m/s
B) 8.0 m/s
C) 150 m/s
D) 170 m/s

105) Which of the following changes would increase the maximum speed at which the go-cart described could travel without sliding off the track?

A) Increase the radius of the track.
B) Decrease the coefficient of friction between the go-cart and the track.
C) Decrease the radius of the track.
D) Increase the mass of the go-cart.

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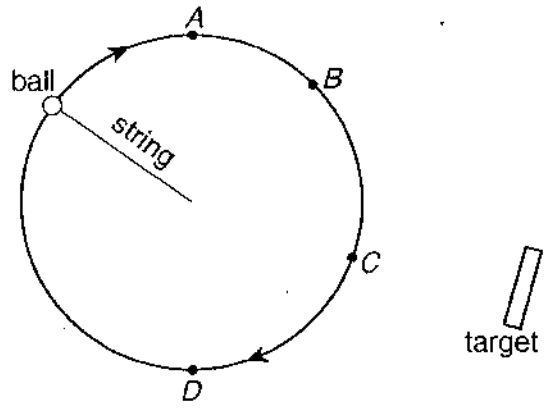
106) A ball attached to a string is moved at constant speed in a horizontal circular path. A target is located near the path of the ball as shown in the diagram below.



At which point along the ball's path should the string be released, if the ball is to hit the target?

A) *A*
B) *B*
C) *C*
D) *D*

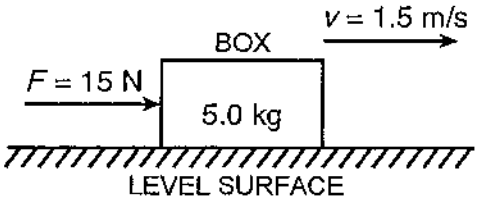
❹ PART 4: Inertial Properties of Objects

♦ Inertia

107) A 0.50-kilogram cart is rolling at a speed of 0.40 meter per second. If the speed of the cart is doubled, the inertia of the cart is

A) unchanged
B) halved
C) doubled
D) quadrupled

108) As shown in the diagram below, an open box and its contents have a combined mass of 5.0 kilograms.



A horizontal force of 15 newtons is required to push the box at a constant speed of 1.5 meters per second across a level surface. The inertia of the box and its contents increases if there is an increase in the

A) mass of the contents of the box
B) speed of the box
C) magnitude of the horizontal force applied to the box
D) coefficient of kinetic friction between the box and the level surface

109) Which of the following objects has the *greatest* inertia?

A) a seated high school student
B) a falling leaf
C) a softball in flight
D) a rising helium-filled toy balloon

110) Which of the following objects has the *greatest* inertia?

A) a 20.-kg object at rest
B) a 5.0-kg object moving at a speed of 5.0 m/s
C) a 10.-kg object moving at a speed of 3.0 m/s
D) a 15-kg object moving at a speed of 1.0 m/s

111) Which of the following objects has the *greatest* inertia?

A) a 20.0-kg mass moving at 1.00 m/s
B) a 5.00-kg mass moving at 10.0 m/s
C) a 10.0-kg mass moving at 1.00 m/s
D) a 15.0-kg mass moving at 10.0 m/s

112) The data table below lists the mass and speed of four different objects.

DATA TABLE

Object	Mass (kg)	Speed (m/s)
A	4.0	6.0
B	6.0	5.0
C	8.0	3.0
D	16.0	1.5

Which object has the *greatest* inertia?

A) *A*
B) *B*
C) *C*
D) *D*

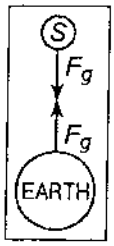
♦ Universal Law of Gravitation

113) Gravitational forces differ from electrostatic forces in that gravitational forces are

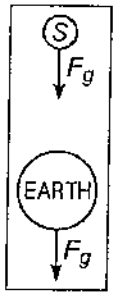
A) attractive, only
B) repulsive, only
C) neither attractive nor repulsive
D) both attractive and repulsive

114) Which diagram *best* represents the gravitational forces, F_g, between a satellite, S, and Earth?

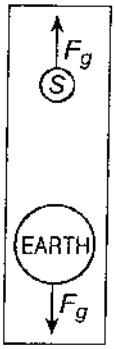
A)



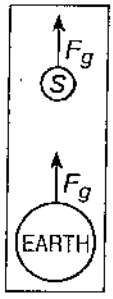
B)



C)

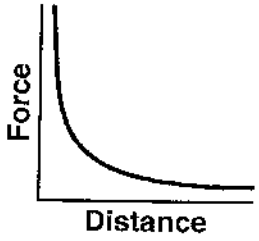


D)

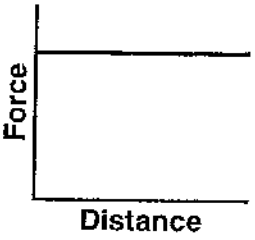


115) A space probe is launched into space from Earth's surface. Which one of the following graphs represents the relationship between the magnitude of the gravitational force exerted on Earth by the space probe and the distance between the space probe and the center of Earth?

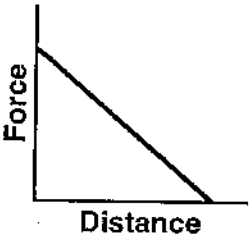
A)



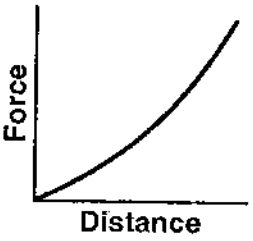
B)



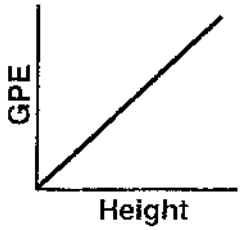
C)



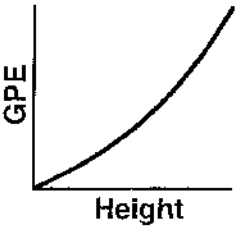
D)

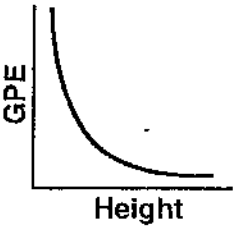


116) Which one of the following graphs represents the relationship between the gravitational potential energy (GPE) of an object near the surface of Earth and its height above the surface of Earth?

A) 

B) 

C) 

D) 

117) Earth's mass is approximately 81 times the mass of the Moon. If Earth exerts a gravitational force of magnitude F on the Moon, the magnitude of the gravitational force of the Moon on Earth is

A) F
B) $\frac{F}{81}$
C) $9F$
D) $81F$

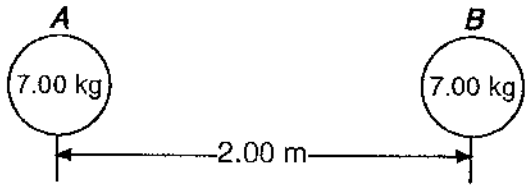
118) As a meteor moves from a distance of 16 Earth radii to a distance of 2 Earth radii from the center of Earth, the magnitude of the gravitational force between the meteor and Earth becomes

A) 64 times as great
B) as great
C) 8 times as great
D) 4 times as great

119) When Earth and the Moon are separated by a distance of 3.84×10^8 meters, the magnitude of the gravitational force of attraction between them is 2.0×10^{20} newtons. What would be the magnitude of this gravitational force of attraction if Earth and the Moon were separated by a distance of 1.92×10^8 meters?

A) 8.0×10^{20} N
B) 5.0×10^{19} N
C) 2.0×10^{20} N
D) 4.0×10^{20} N

120) The diagram shows two bowling balls, A and B, each having a mass of 7.00 kilograms, placed 2.00 meters apart.



What is the magnitude of the gravitational force exerted by ball A on ball B?

A) 8.17×10^{-10} N
B) 1.17×10^{-10} N
C) 1.63×10^{-9} N
D) 8.17×10^{-9} N

♦ Weight and Gravity

121) As an astronaut travels from the surface of Earth to a position that is four times as far away from the center of Earth, the astronaut's

A) mass remains the same
B) mass decreases
C) weight increases
D) weight remains the same

122) On the surface of Earth, a spacecraft has a mass of 2.00×10^4 kilograms. What is the mass of the spacecraft at a distance of one Earth radius above Earth's surface?

A) 2.00×10^4 kg
B) 5.00×10^3 kg
C) 4.90×10^4 kg
D) 1.96×10^5 kg

123) A 2.00-kilogram object weighs 19.6 newtons on Earth. If the acceleration due to gravity on Mars is 3.71 meters per second^2, what is the object's mass on Mars?

A) 2.00 kg
B) 2.64 kg
C) 19.6 N
D) 7.42 N

124) What is the acceleration due to gravity at a location where a 15.0-kilogram mass weighs 45.0 newtons?

A) 3.00 m/s^2
B) 675 m/s^2
C) 9.81 m/s^2
D) 0.333 m/s^2

125) A 60.-kilogram physics student would weigh 1,560 newtons on the surface of planet *X*. What is the magnitude of the acceleration due to gravity on the surface of planet *X*?

A) 26 m/s^2
B) 0.038 m/s^2
C) 6.1 m/s^2
D) 9.8 m/s^2

126) A person weighing 785 newtons on the surface of Earth would weigh 298 newtons on the surface of Mars. What is the magnitude of the gravitational field strength on the surface of Mars?

A) 3.72 N/kg
B) 2.63 N/kg
C) 6.09 N/kg
D) 9.81 N/kg

127) What is the weight of a 2.00-kilogram object on the surface of Earth?

A) 19.6 N
B) 4.91 N
C) 2.00 N
D) 9.81 N

128) The weight of a typical high school physics student is *closest* to

A) 600 N
B) 1,500 N
C) 120 N
D) 60 N

♦ Momentum and Conservation of Momentum

129) Cart *A* has a mass of 2 kilograms and a speed of 3 meters per second. Cart *B* has a mass of 3 kilograms and a speed of 2 meters per second. Compared to the inertia and magnitude of momentum of cart *A*, cart *B* has

A) greater inertia and the same magnitude of momentum
B) the same inertia and a smaller magnitude of momentum
C) the same inertia and the same magnitude of momentum
D) greater inertia and a smaller magnitude of momentum

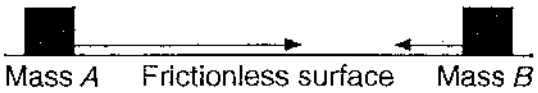
130) Which of the following situations will produce the *greatest* change of momentum for a 1.0-kilogram cart?

A) applying a net force of 5.0 N for 2.0 s
B) accelerating it from rest to 3.0 m/s
C) accelerating it from 2.0 m/s to 4.0 m/s
D) applying a net force of 10.0 N for 0.5 s

131) A 1.0-kilogram laboratory cart moving with a velocity of 0.50 meter per second due east collides with and sticks to a similar cart initially at rest. After the collision, the two carts move off together with a velocity of 0.25 meter per second due east. The total momentum of this frictionless system is

A) the same before and after the collision
B) zero before the collision
C) zero after the collision
D) greater before the collision than after the collision

132) In the diagram below, scaled vectors represent the momentum of each of two masses, *A* and *B*, sliding toward each other on a frictionless, horizontal surface.



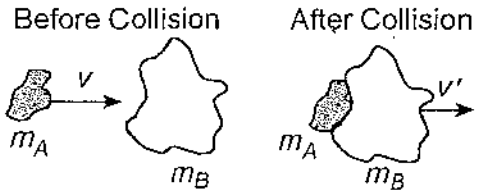
Which of the following scaled vectors *best* represents the momentum of the system after the masses collide?

A)
B)
C)
D)

133) A woman with horizontal velocity v_1 jumps off a dock into a stationary boat. After landing in the boat, the woman and the boat move with velocity v_2. Compared to velocity v_1, velocity v_2 has

A) smaller magnitude and the same direction
B) the same magnitude and the same direction
C) the same magnitude and opposite direction
D) larger magnitude and the same direction

134) The diagram below represents two masses before and after they collide. Before the collision, mass m_A is moving to the right with speed v, and mass m_B is at rest. Upon collision, the two masses stick together.



Which expression represents the speed, v', of the masses after the collision? [*Assume no outside forces are acting on m_A or m_B.*]

A) $\frac{m_A v}{m_A + m_B}$

B) $\frac{m_A + m_B v}{m_A}$

C) $\frac{m_A + m_B}{m_A v}$

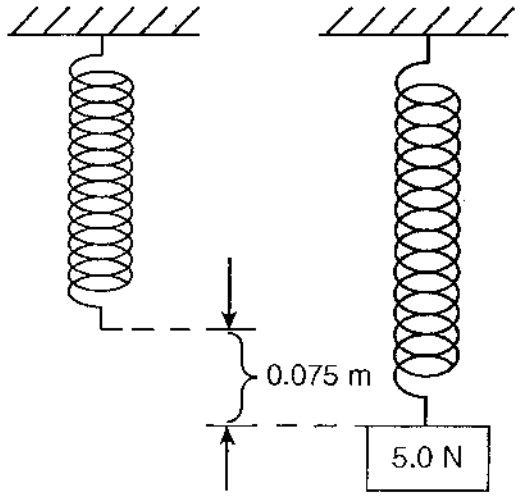
D) $\frac{m_B v}{m_A + m_B}$

135) A 3.1-kilogram gun initially at rest is free to move. When a 0.015-kilogram bullet leaves the gun with a speed of 500. meters per second, what is the speed of the gun?

A) 2.4 m/s
B) 0.0 m/s
C) 7.5 m/s
D) 500. m/s

❺ PART 5: Spring Constant

136) The diagram below represents a spring hanging vertically that stretches 0.075 meter when a 5.0-newton block is attached. The spring-block system is at rest in the position shown.



What is the value of the spring constant?

A) 67 N/m
B) 38 N/m
C) 130 N/m
D) 650 N/m

137) An unstretched spring has a length of 10. centimeters. When the spring is stretched by a force of 16 newtons, its length is increased to 18 centimeters. What is the spring constant of this spring?

A) 2.0 N/cm
B) 0.89 N/cm
C) 1.6 N/cm
D) 1.8 N/cm

138) A spring with a spring constant of 4.0 newtons per meter is compressed by a force of 1.2 newtons. What is the total elastic potential energy stored in this compressed spring?

A) 0.18 J
B) 0.36 J
C) 0.60 J
D) 4.8 J

⑥ PART 6: Impulse

139) A 0.45-kilogram football traveling at a speed of 22 meters per second is caught by an 84-kilogram stationary receiver. If the football comes to rest in the receiver's arms, what is the magnitude of the impulse imparted to the receiver by the ball?

A) 9.9 N • s
B) 1,800 N • s
C) 4.4 N • s
D) 3.8 N • s

140) A 6.0-kilogram block, sliding to the east across a horizontal, frictionless surface with a momentum of 30. kilogram • meters per second, strikes an obstacle. The obstacle exerts an impulse of 10. newton • seconds to the west on the block. What is the speed of the block after the collision?

A) 3.3 m/s
B) 1.7 m/s
C) 5.0 m/s
D) 20. m/s

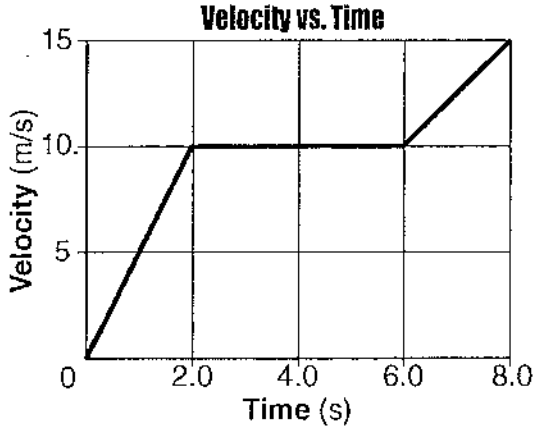
TOPIC E: *Constructed Response Questions*

❶ PART 1: Measurement

141) A person walks 150. meters due east and then walks 30. meters due west. The entire trip takes the person 10. minutes. Determine the magnitude and the direction of the person's total displacement.

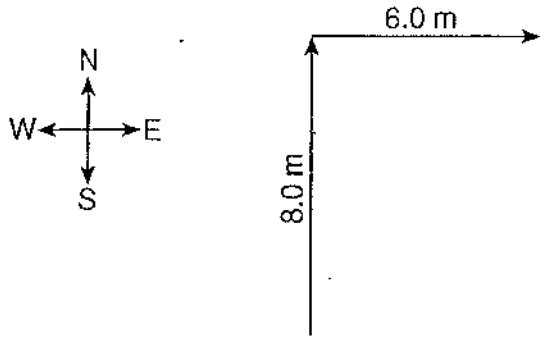
142) A cart travels 4.00 meters east and then 4.00 meters north. Determine the magnitude of the cart's resultant displacement.

143) The graph below represents the velocity of an object traveling in a straight line as a function of time.



Determine the magnitude of the total displacement of the object at the end of the first 6.0 seconds.

144) A dog walks 8.0 meters due north and then 6.0 meters due east.



(a) Using a metric ruler and the given vector diagram, determine the scale used in the diagram.

(b) On the diagram provided, construct the resultant vector that represents the dog's total displacement.

(c) Determine the magnitude of the dog's total displacement.

145) The instant before a batter hits a 0.14-kilogram baseball, the velocity of the ball is 45 meters per second west. The instant after the batter hits the ball, the ball's velocity is 35 meters per second east. The bat and ball are in contact for 1.0×10^{-2} second.

(a) Determine the magnitude and direction of the average acceleration of the given baseball while it is in contact with the bat.

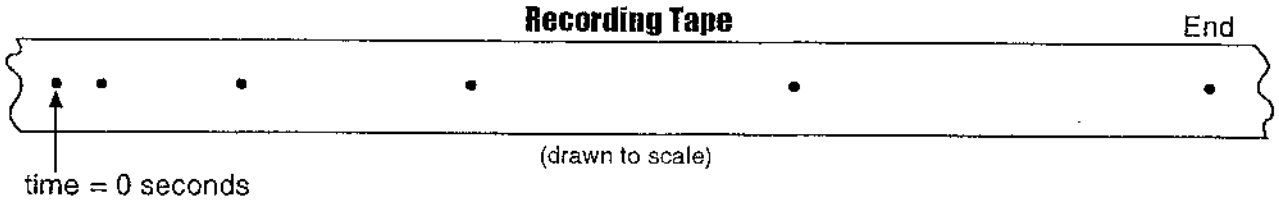
(b) Calculate the magnitude of the average force the bat exerts on the given ball while they are in contact. [*Show all work, including the equation and substitution with units.*]

PART 2: KINEMATICS

ACCELERATED MOTION

Questions 146 and 147 refer to the following:

A spark timer is used to record the position of a lab cart accelerating uniformly from rest. Each 0.10 second, the timer marks a dot on a recording tape to indicate the position of the cart at that instant, as shown below.



146) (a) Using a metric ruler, measure the distance the cart described traveled during the interval $t = 0$ second to $t = 0.30$ second. [*Record your answer to the nearest tenth of a centimeter.*]

(b) Calculate the magnitude of the acceleration of the cart during the time interval $t = 0$ second to $t = 0.30$ second. [*Show all work, including the equation and substitution with units.*]

(c) Calculate the average speed of the cart during the time interval $t = 0$ second to $t = 0.30$ second. [*Show all work, including the equation and substitution with units.*]

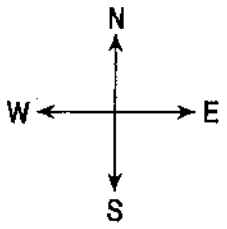
147) On the diagram provided below, mark at least four dots to indicate the position of a cart traveling at a constant velocity.

Questions 148 and 149 refer to the following:

A 747 jet, traveling at a velocity of 70. meters per second north, touches down on a runway. The jet slows to rest at the rate of 2.0 meters per second^2.

148) Calculate the total distance the jet in the given situation travels on the runway as it is brought to rest. [*Show all work, including the equation and substitution with units.*]

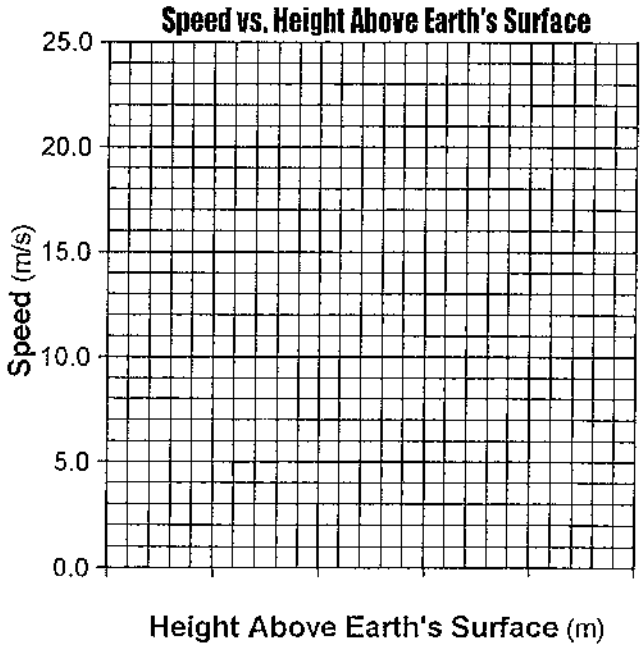
149) On the diagram below, point *P* represents the position of the given jet on the runway. Beginning at point *P*, draw a vector to represent the magnitude and direction of the acceleration of the jet as it comes to rest. Use a scale of 1.0 centimeter = 0.50 meter/second^2.



150) A 1.00-kilogram mass was dropped from rest from a height of 25.0 meters above Earth's surface. The speed of the mass was determined at 5.0-meter intervals and recorded in the data table below.

DATA TABLE:

Height Above Earth's Surface (m)	Speed (m/s)
25.0	0.0
20.0	9.9
15.0	14.0
10.0	17.1
5.0	19.8
0	22.1



Using the information in the data table, construct a graph on the grid provided following the directions below:

(a) Mark an appropriate scale on the axis labeled "Height Above Earth's Surface (m)."

(b) Plot the data points for speed versus height above Earth's surface.

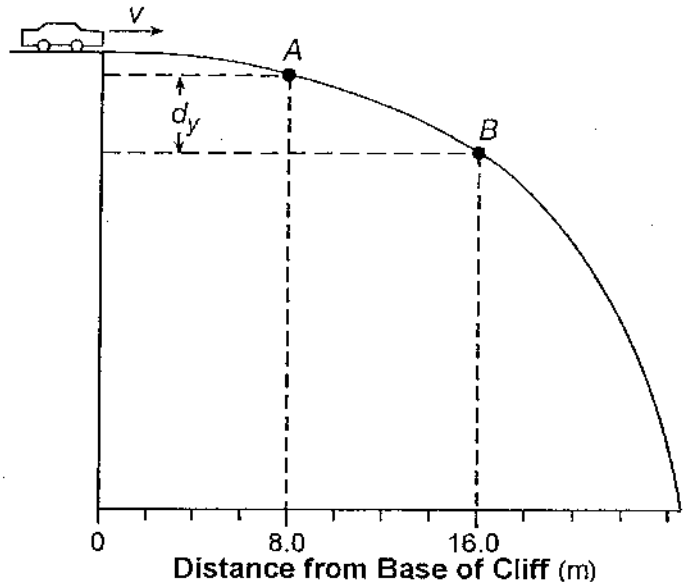
(c) Draw the line or curve of best fit.

(d) Using your graph, determine the speed of the mass after it has fallen a vertical distance of 12.5 meters.

◆ Projectiles and Trajectories

Questions 151 and 152 refer to the following:

The path of a stunt car driven horizontally off a cliff is represented in the diagram below. After leaving the cliff, the car falls freely to point *A* in 0.50 second and to point *B* in 1.00 second.



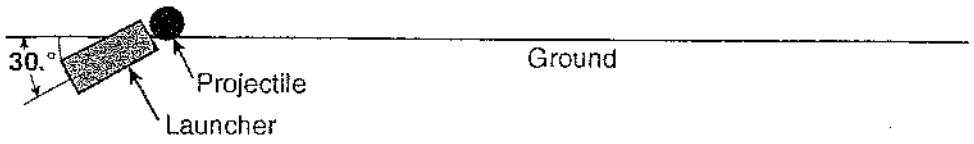
151) Determine the magnitude of the horizontal component of the velocity of the car at point *B* in the given diagram. [*Neglect friction.*]

152) (a) Determine the magnitude of the vertical velocity of the car at point *A* in the given diagram.

(b) Calculate the magnitude of the vertical displacement, d_y, of the given car from point *A* to point *B*. [*Neglect friction.*] [*Show all work, including the equation and substitution with units.*]

Questions 153 through 155 refer to the following:

A projectile is launched into the air with an initial speed of v_i at a launch angle of 30.° above the horizontal as shown below. The projectile lands on the ground 2.0 seconds later.



153) On the diagram provided, sketch the ideal path of the projectile.

154) How does the maximum altitude of the projectile described change as the launch angle is increased from 30.° to 45° above the horizontal? [*Assume the same initial speed, v_i.*]

155) How does the total horizontal distance traveled by the projectile described change as the launch angle is increased from 30.° to 45° above the horizontal? [*Assume the same initial speed, v_i.*]

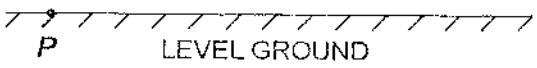
Questions 156 and 157 refer to the following:

A kicked soccer ball has an initial velocity of 25 meters per second at an angle of 40.° above the horizontal, level ground. [*Neglect friction.*]

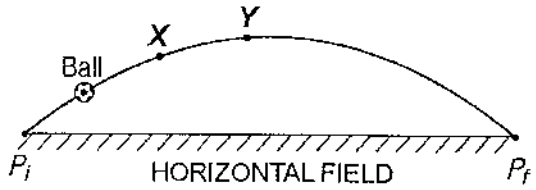
156) (a) Calculate the magnitude of the vertical component of the given ball's initial velocity. [*Show all work, including the equation and substitution with units.*]

(b) Calculate the maximum height the ball reaches above its initial position. [*Show all work, including the equation and substitution with units.*]

157) On the diagram below, sketch the path of the given ball's flight from its initial position at point *P* until it returns to level ground.



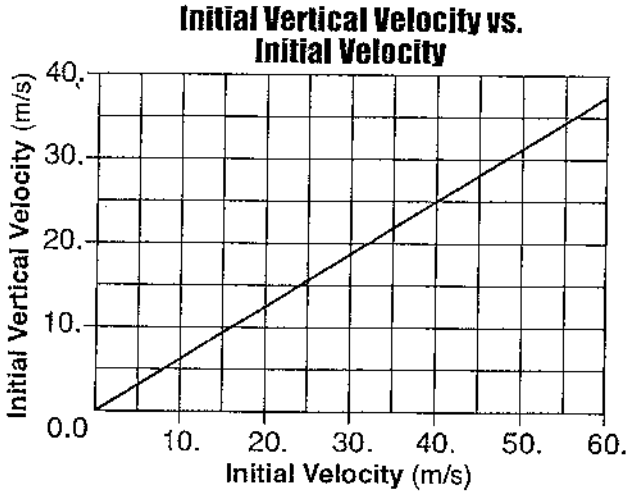
158) A soccer ball is kicked from point P_i at an angle above a horizontal field. The ball follows an ideal path before landing on the field at point P_f. A diagram is provided below.



(a) On the diagram provided, draw an arrow to represent the direction of the net force on the ball when it is at position *X*. Label the arrow F_{net}. [*Neglect friction.*]

(b) On the same diagram, draw an arrow to represent the direction of the acceleration of the ball at position *Y*. Label the arrow *a*. [*Neglect friction.*]

159) A machine fired several projectiles at the same angle, θ, above the horizontal. Each projectile was fired with a different initial velocity, v_i. The graph below represents the relationship between the magnitude of the initial vertical velocity, v_{iy}, and the magnitude of the corresponding initial velocity, v_i, of these projectiles.



(a) Determine the magnitude of the initial vertical velocity of the projectile, v_{iy}, when the magnitude of its initial velocity, v_i, was 40. meters per second.

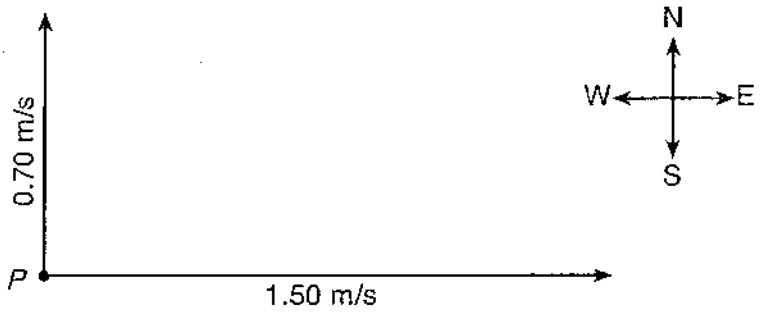
(b) Determine the angle, θ, above the horizontal at which the given projectiles were fired.

(c) Calculate the magnitude of the initial horizontal velocity of the given projectile, v_{ix}, when the magnitude of its initial velocity, v_i, was 40. meters per second. [*Show all work, including the equation and substitution with units.*]

PART 3: Net Force and Equilibrium

160) A 0.50-kilogram frog is at rest on the bank surrounding a pond of water. As the frog leaps from the bank, the magnitude of the acceleration of the frog is 3.0 meters per second^2. Calculate the magnitude of the net force exerted on the frog as it leaps. [*Show all work, including the equation and substitution with units.*]

161) A model airplane heads due east at 1.50 meters per second, while the wind blows due north at 0.70 meter per second. The scaled diagram below represents these vector quantities.



(a) Using a ruler, determine the scale used in the vector diagram.

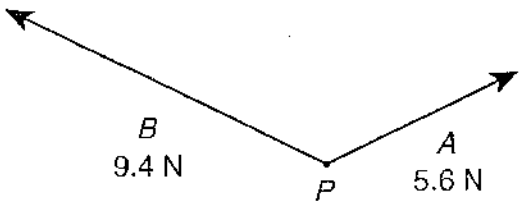
(b) On the diagram provided, use a protractor and a ruler to construct a vector to represent the resultant velocity of the airplane. Label the vector *R*.

(c) Determine the magnitude of the resultant velocity.

(d) Determine the angle between north and the resultant velocity.

Questions 162 through 164 refer to the following:

Force *A* with a magnitude of 5.6 newtons and force *B* with a magnitude of 9.4 newtons act concurrently on point *P*.



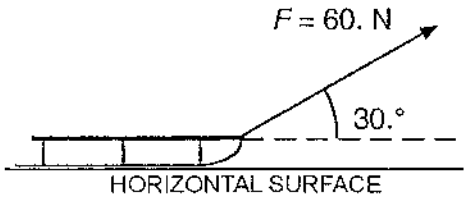
162) Determine the scale used in the given diagram.

163) On the diagram provided, use a ruler and protractor to construct a vector representing the resultant of forces *A* and *B*.

164) Using the given information, determine the magnitude of the resultant force of vectors *A* and *B*.

Questions 165 and 166 refer to the following:

A force of 60. newtons is applied to a rope to pull a sled across a horizontal surface at a constant velocity as shown below. The rope is at an angle of 30. degrees above the horizontal.



165) Using the given information, calculate the magnitude of the component of the 60.-newton force that is parallel to the horizontal surface. [*Show all work, including the equation and substitution with units.*]

166) Using the given information, determine the magnitude of the frictional force acting on the sled.

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167) A 1,500-kilogram car accelerates at 5.0 meters per second^2 on a level, dry, asphalt road. Determine the magnitude of the net horizontal force acting on the car.

PART 4: STATIC AND DYNAMIC SYSTEMS

FORCES IN A DYNAMIC SYSTEM

168) A 70-kilogram hockey player skating east on an ice rink is hit by a 0.1-kilogram hockey puck moving toward the west. The puck exerts a 50-newton force toward the west on the player. Determine the magnitude of the force that the player exerts on the puck during this collision.

169) A student and the waxed skis he is wearing have a combined weight of 850 newtons. The skier travels down a snow-covered hill and then glides to the east across a snow-covered, horizontal surface.

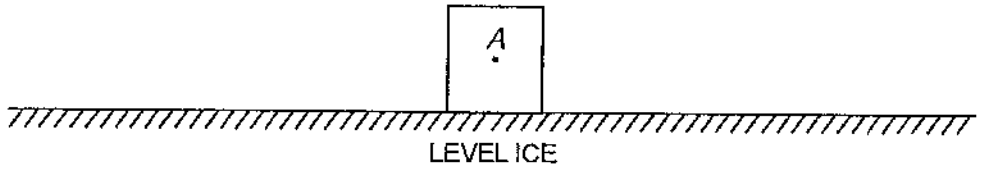
(a) Determine the magnitude of the normal force exerted by the snow on the skis as the skier glides across the horizontal surface.

(b) Calculate the magnitude of the force of friction acting on the skis as the skier glides across the snow-covered, horizontal surface. [*Show all work, including the equation and substitution with units.*]

170) An ice skater applies a horizontal force to a 20.-kilogram block on frictionless, level ice, causing the block to accelerate uniformly at 1.4 meters per second^2 to the right. After the skater stops pushing the block, it slides onto a region of ice that is covered with a thin layer of sand. The coefficient of kinetic friction between the block and the sand-covered ice is 0.28.

(a) Calculate the magnitude of the force applied to the block shown by the skater. [*Show all work, including the equation and substitution with units.*]

(b) On the diagram below, starting at point *A*, draw a vector to represent the force applied to the block by the skater in the given experiment. Begin the vector at point *A* and use a scale of 1.0 centimeter = 5.0 newtons.

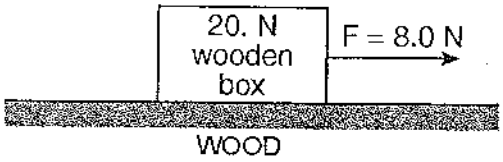


(c) Determine the magnitude of the normal force acting on the block in the given experiment.

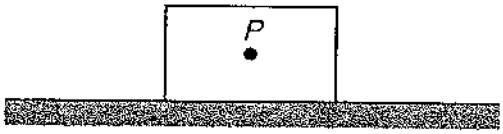
(d) Calculate the magnitude of the force of friction acting on the block as it slides over the sand-covered ice. [*Show all work, including the equation and substitution with units.*]

Questions 171 through 173 refer to the following:

A horizontal force of 8.0 newtons is used to pull a 20.-newton wooden box moving toward the right along a horizontal; wood surface, as shown below.



171) Starting at point P on the diagram below, use a metric ruler and a scale of 1.0 cm = 4.0 N to draw a vector representing the normal force acting on the box. Label the vector F_N.



172) Calculate the magnitude of the frictional force acting on the box described. [*Show all work, including the equation and substitution with units.*]

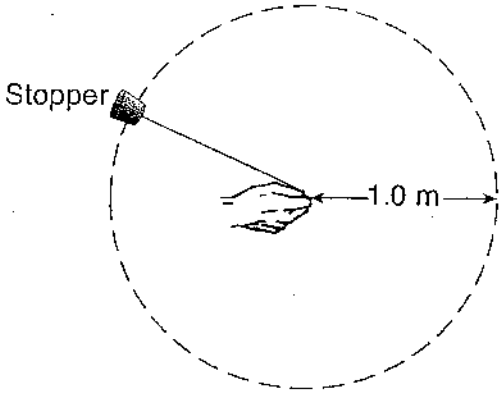
173) (a) Determine the magnitude of the net force acting on the box decribed.

(b) Determine the mass of the box described.

(c) Calculate the magnitude of the acceleration of the box described. [*Show all work, including the equation and substitution with units.*]

◆ Uniform Circular Motion

174) In an experiment, a 0.028-kilogram rubber stopper is attached to one end of a string. A student whirls the stopper overhead in a horizontal circle with a radius of 1.0 meter. The stopper completes 10. revolutions in 10. seconds.



(not drawn to scale)

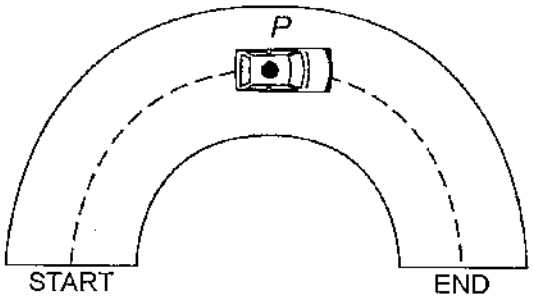
(a) Determine the speed of the whirling stopper in the given experiment.

(b) Calculate the magnitude of the centripetal force on the whirling stopper in the given experiment. [*Show all work, including the equation and substitution with units.*]

175) A baby and stroller have a total mass of 20. kilograms. A force of 36 newtons keeps the stroller moving in a circular path with a radius of 5.0 meters. Calculate the speed at which the stroller moves around the curve. [*Show all work, including the equation and substitution with units.*]

176) Calculate the magnitude of the centripetal force acting on Earth as it orbits the Sun, assuming a circular orbit and an orbital speed of 3.00×10^4 meters per second. [*Show all work, including the equation and substitution with units.*]

177) A car travels at constant speed around a section of horizontal, circular track. On the diagram provided below, draw an arrow at point *P* to represent the direction of the centripetal acceleration of the car when it is at point *P*.



178) Io (pronounced "EYE oh") is one of Jupiter's moons discovered by Galileo. Io is slightly larger than Earth's Moon. The mass of Io is 8.93×10^{22} kilograms and the mass of Jupiter is 1.90×10^{27} kilograms. The distance between the centers of Io and Jupiter is 4.22×10^8 meters.

(a) Calculate the magnitude of the gravitational force of attraction that Jupiter exerts on Io. [*Show all work, including the equation and substitution with units.*]

(b) Calculate the magnitude of the acceleration of Io due to the gravitational force exerted by Jupiter. [*Show all work, including the equation and substitution with units.*]

◆ Inertial Properties of Objects

179) On a snow-covered road, a car with a mass of 1.1×10^3 kilograms collides head-on with a van having a mass of 2.5×10^3 kilograms traveling at 8.0 meters per second. As a result of the collision, the vehicles lock together and immediately come to rest. Calculate the speed of the car immediately before the collision. [*Neglect friction.*] [*Show all work, including the equation and substitution with units.*]

Questions 180 and 181 refer to the following:

A 1,200-kilogram car moving at 12 meters per second collides with a 2,300-kilogram car that is waiting at rest at a traffic light. After the collision, the cars lock together and slide. Eventually, the combined cars are brought to rest by a force of kinetic friction as the rubber tires slide across the dry, level, asphalt road surface.

180) Calculate the speed of the locked-together cars immediately after the collision described in the reading passage. [*Show all work, including the equation and substitution with units.*]

181) Calculate the magnitude of the frictional force that brings the locked-together cars described in the reading passage to rest. [*Show all work, including the equation and substitution with units.*]

◆ Spring Constant

182) When a spring is compressed 2.50×10^{-2} meter from its equilibrium position, the total potential energy stored in the spring is 1.25×10^{-2} joule. Calculate the spring constant of the spring. [*Show all work, including the equation and substitution with units.*]

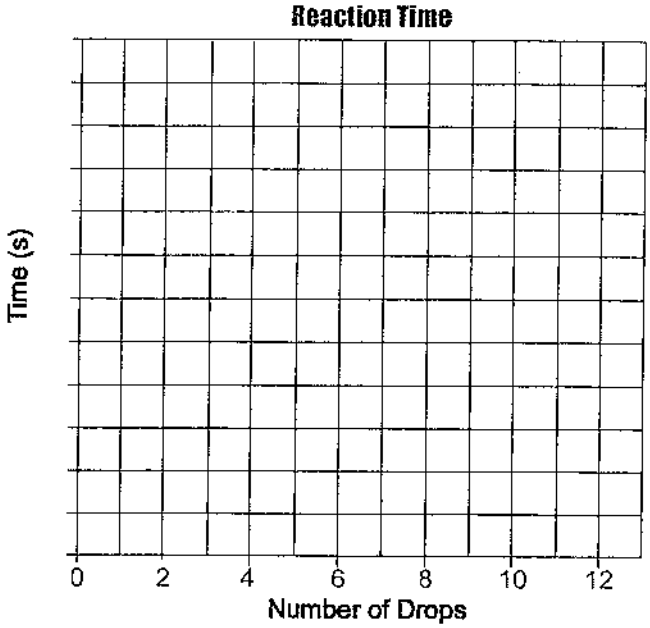
183) A spring in a toy car is compressed a distance, x. When released, the spring returns to its original length, transferring its energy to the car. Consequently, the car having mass m moves with speed v.

Derive the spring constant, k, of the car's spring in terms of m, x, and v. [*Assume an ideal mechanical system with no loss of energy.*] [*Show all work, including the equations used to derive the spring constant.*]

184) A 10.-newton force compresses a spring 0.25 meter from its equilibrium position. Calculate the spring constant of this spring. [*Show all work, including the equation and substitution with units.*]

185) In a laboratory investigation, a student applied various downward forces to a vertical spring. The applied forces and the corresponding elongations of the spring from its equilibrium position are recorded in the data table below.

Test Tube	Number of Drops of 0.02 M KIO3(aq)	Time for Dark-Blue Color to Appear (s)
A	2	210.
B	4	88
C	6	49
D	8	39
E	10	33
F	12	27



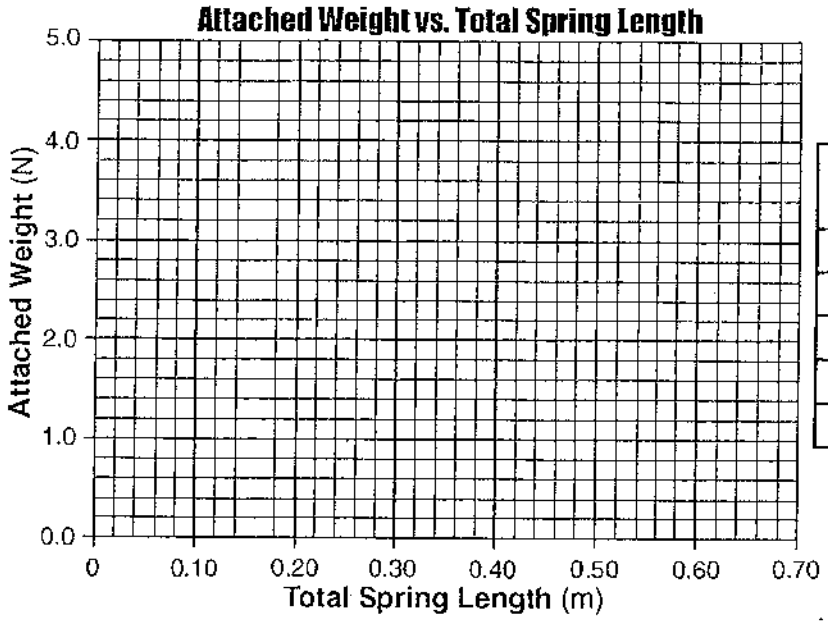
(a) Mark an appropriate scale on the axis provided labeled "Force (N)."

(b) Plot the given data points for force versus elongation.

(c) Draw the best-fit line or curve.

(d) Using your graph, calculate the spring constant of this spring. [*Show all work, including the equation and substitution with units.*]

186) A student performed an experiment in which the weight attached to a suspended spring was varied and the resulting total length of the spring measured. The data for the experiment are in the table below.



Attached Weight vs. Total Spring Length

Attached Weight (N)	Total Spring Length (m)
0.98	0.37
1.96	0.42
2.94	0.51
3.92	0.59
4.91	0.64

Using the information in the data table above, construct a graph on the grid provided, following the directions below.

(a) Plot the data points for the attached weight versus total spring length.

(b) Draw the line or curve of best fit.

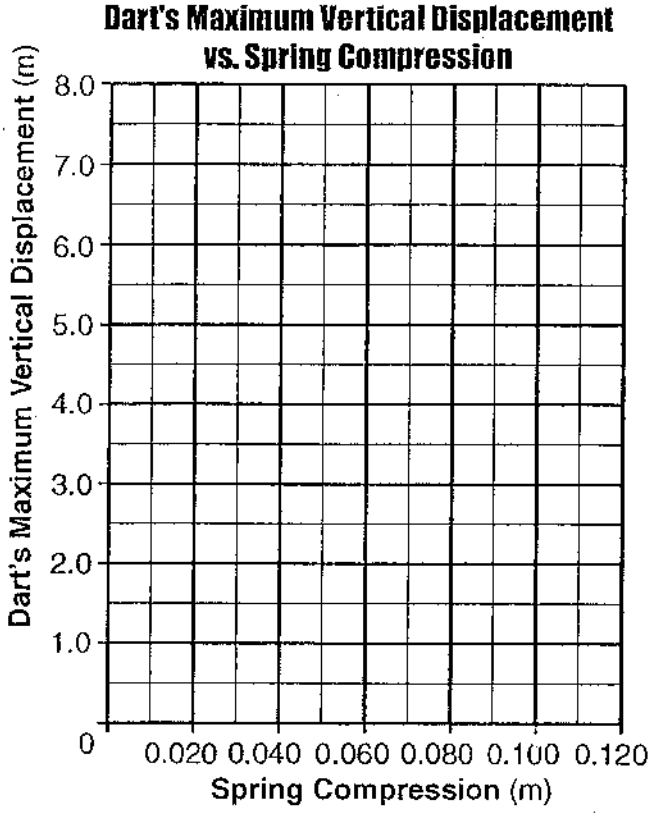
(c) Based on your graph, determine the length of the spring before any weight was attached.

Questions 187 and 188 refer to the following:

The spring in a dart launcher has a spring constant of 140 newtons per meter. The launcher has six power settings, 0 through 5, with each successive setting having a spring compression 0.020 meter beyond the previous setting. During testing, the launcher is aligned to the vertical, the spring is compressed, and a dart is fired upward. The maximum vertical displacement of the dart in each test trial is measured. The results of the testing are shown in the table below.

DATA TABLE:

Power Setting	Spring Compression (m)	Dart's Maximum Vertical Displacement (m)
0	0.000	0.00
1	0.020	0.29
2	0.040	1.14
3	0.060	2.57
4	0.080	4.57
5	0.100	7.10



187) Using the information in the data table shown, construct a graph on the grid provided following the directions below.

(a) Plot the data points for the dart's maximum vertical displacement versus spring compression.

(b) Draw the line or curve of best fit.

(c) Calculate the energy provided by the compressed spring that causes the dart to achieve a maximum vertical displacement of 3.50 meters. [*Show all work, including the equation and substitution with units.*]

188) Based on the given information, determine the magnitude of the force, in newtons, needed to compress the spring 0.040 meter.

◆ Impulse

189) Calculate the magnitude of the impulse applied to a 0.75-kilogram cart to change its velocity from 0.50 meter per second east to 2.00 meters per second east. [*Show all work, including the equation and substitution with units.*]

WORK & ENERGY

TOPIC A: *Work*

190) A joule is equivalent to a

A) N•m C) N/m
B) N•s D) N/s

191) Which of the following is an SI unit for work done on an object?

A) $\frac{kg \cdot m^2}{s^2}$ C) $\frac{kg \cdot m}{s}$
B) $\frac{kg \cdot m^2}{s}$ D) $\frac{kg \cdot m}{s^2}$

192) The work done in lifting an apple one meter near Earth's surface is approximately

A) 1 J C) 100 J
B) 0.01 J D) 1,000 J

193) How much work is required to lift a 10.-newton weight from 4.0 meters to 40. meters above the surface of Earth?

A) 3.6×10^2 J C) 3.6 J
B) 2.5 J D) 4.0×10^2 J

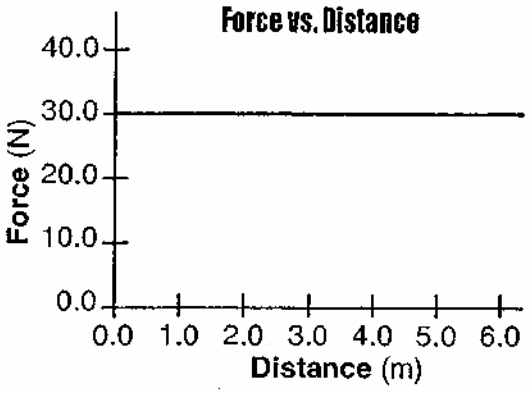
194) The total work done in lifting a typical high school physics textbook a vertical distance of 0.10 meter is approximately

A) 1.5 J C) 15 J
B) 0.15 J D) 150 J

195) A 60.-kilogram student climbs a ladder a vertical distance of 4.0 meters in 8.0 seconds. Approximately how much total work is done against gravity by the student during the climb?

A) 2.4×10^3 J C) 2.4×10^2 J
B) 2.9×10^2 J D) 3.0×10^1 J

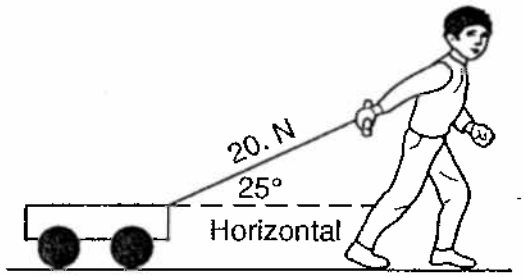
196) A boy pushes his wagon at constant speed along a level sidewalk. The graph below represents the relationship between the horizontal force exerted by the boy and the distance the wagon moves.



In the given situation, what is the total work done by the boy in pushing the wagon 4.0 meters?

A) 120 J C) 7.5 J
B) 5.0 J D) 180 J

197) As shown in the diagram below, a child applies a constant 20.-newton force along the handle of a wagon which makes a 25° angle with the horizontal.



How much work does the child do in moving the wagon a horizontal distance of 4.0 meters?

A) 73 J C) 34 J
B) 5.0 J D) 80. J

198) A 15.0-kilogram mass is moving at 7.50 meters per second on a horizontal, frictionless surface. What is the total work that must be done on the mass to increase its speed to 11.5 meters per second?

A) 570. J C) 422 J
B) 120. J D) 992 J

199) A child does 0.20 joule of work to compress the spring in a pop-up toy. If the mass of the toy is 0.010 kilogram, what is the maximum vertical height that the toy can reach after the spring is released?

A) 2.0 m C) 0.20 m
B) 20. m D) 0.020 m

200) The work done on a slingshot is 40.0 joules to pull back a 0.10-kilogram stone. If the slingshot projects the stone straight up in the air, what is the maximum height to which the stone will rise? [*Neglect friction.*]

A) 41 m C) 410 m
B) 0.41 m D) 4.1 m

201) What is the maximum amount of work that a 6,000.-watt motor can do in 10. seconds?

A) 6.0×10^4 J C) 6.0×10^2 J
B) 6.0×10^1 J D) 6.0×10^3 J

202) What is the total amount of work required to move a proton through a potential difference of 100. volts?

A) 1.60×10^{-17} J
B) 1.60×10^{-21} J
C) 1.00×10^2 J
D) 6.25×10^{20} J

TOPIC B: *Energy*

PART 1: Introduction to Energy (Kinetic and Potential Energy)

203) Which combination of fundamental units can be used to express energy?

A) $kg \cdot m^2/s^2$ C) $kg \cdot m^2/s$
B) $kg \cdot m/s$ D) $kg \cdot m/s^2$

204) The work done in accelerating an object along a frictionless horizontal surface is equal to the change in the object's

A) kinetic energy
B) momentum
C) velocity
D) potential energy

205) A car with mass m possesses momentum of magnitude p. Which expression correctly represents the kinetic energy, KE, of the car in terms of m and p?

A) $KE = \frac{1}{2}\left(\frac{p^2}{m}\right)$

B) $KE = \frac{1}{2}\left(\frac{p}{m}\right)$

C) $KE = \frac{1}{2}mp^2$

D) $KE = \frac{1}{2}mp$

206) If the speed of a moving object is doubled, the kinetic energy of the object is

A) quadrupled C) doubled
B) halved D) unchanged

207) The table below lists the mass and speed of each of four objects.

Data Table

Objects	Mass (kg)	Speed (m/s)
A	1.0	4.0
B	2.0	2.0
C	0.5	4.0
D	4.0	1.0

Which two objects have the same kinetic energy?

A) *B* and *C* C) *B* and *D*
B) *A* and *D* D) *A* and *C*

208) A 75-kilogram bicyclist coasts down a hill at a constant speed of 12 meters per second. What is the kinetic energy of the bicyclist?

A) 5.4×10^3 J
B) 4.5×10^2 J
C) 9.0×10^2 J
D) 1.1×10^4 J

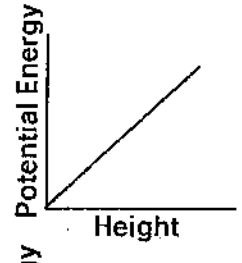
209) A horizontal force of 5.0 newtons acts on a 3.0-kilogram mass over a distance of 6.0 meters along a horizontal, frictionless surface. What is the change in kinetic energy of the mass during its movement over the 6.0-meter distance?

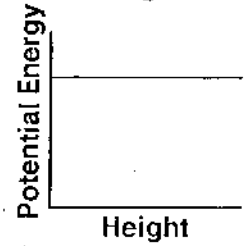
A) 30. J
B) 6.0 J
C) 15 J
D) 90. J

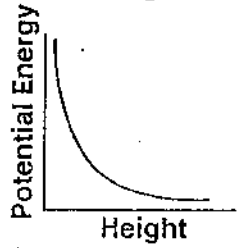
210) The gravitational potential energy, with respect to Earth, that is possessed by an object is dependent on the object's

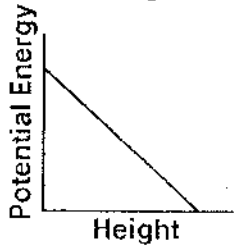
A) position
B) acceleration
C) momentum
D) speed

211) Which of the following graphs *best* represents the relationship between the gravitational potential energy of an object near the surface of Earth and its height above Earth's surface?

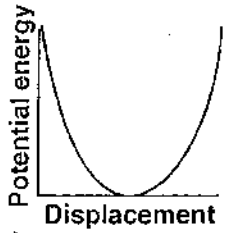
A)


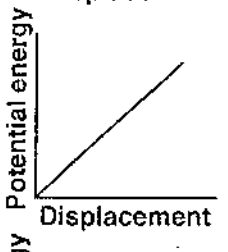
B)


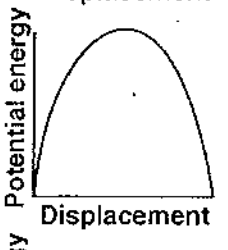
C)


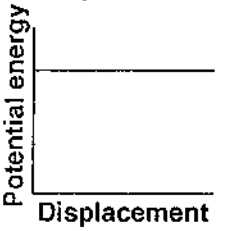
D)


212) A pendulum is pulled to the side and released from rest. Which of the following graphs *best* represents the relationship between the gravitational potential energy of the pendulum and its displacement from its point of release?

A)


B)


C)


D)


213) Which of the following situations describes a system with decreasing gravitational potential energy?

A) a boy jumping down from a tree limb
B) a girl stretching a horizontal spring
C) a bicyclist riding up a steep hill
D) a rocket rising vertically from Earth

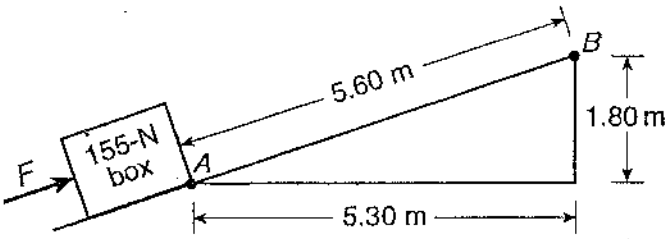
214) A 1.00-kilogram ball is dropped from the top of a building. Just before striking the ground, the ball's speed is 12.0 meters per second. What was the ball's gravitational potential energy, relative to the ground, at the instant it was dropped? [*Neglect friction.*]

A) 72.0 J
B) 6.00 J
C) 24.0 J
D) 144 J

215) While riding a chairlift, a 55-kilogram skier is raised a vertical distance of 370 meters. What is the total change in the skier's gravitational potential energy?

A) 2.0×10^5 J
B) 5.4×10^1 J
C) 5.4×10^2 J
D) 2.0×10^4 J

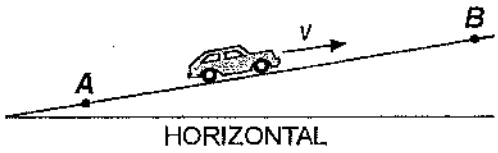
216) The diagram below represents a 155-newton box on a ramp. Applied force F causes the box to slide from point A to point B.



What is the total amount of gravitational potential energy gained by the box?

A) 279 J B) 28.4 J C) 868 J D) 2,740 J

217) A car travels at constant speed v up a hill from point A to point B, as shown in the diagram below.

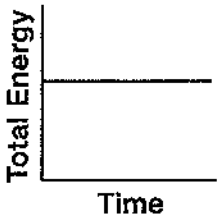


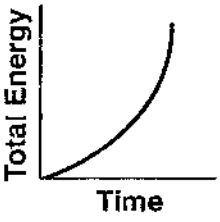
As the car travels from A to B, its gravitational potential energy

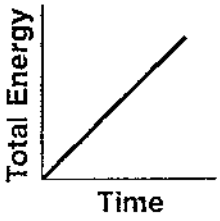
A) increases and its kinetic energy remains the same
B) increases and its kinetic energy decreases
C) remains the same and its kinetic energy decreases
D) remains the same and its kinetic energy remains the same

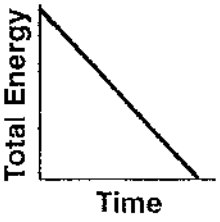
❷ PART 2: Conservation of Energy

218) A ball is dropped from the top of a cliff. Which graph *best* represents the relationship between the ball's total energy and elapsed time as the ball falls to the ground? [*Neglect friction.*]

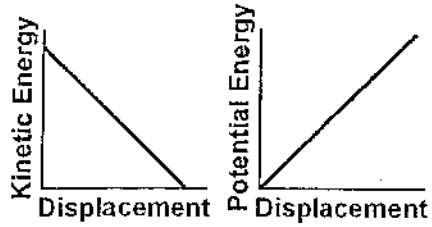
A)


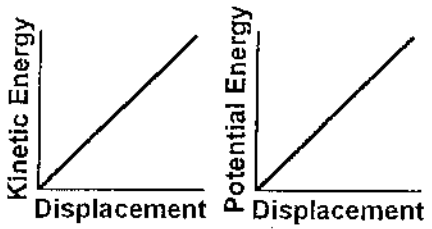
C)


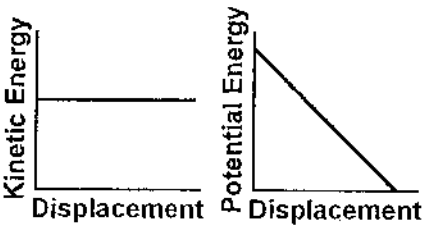
B)


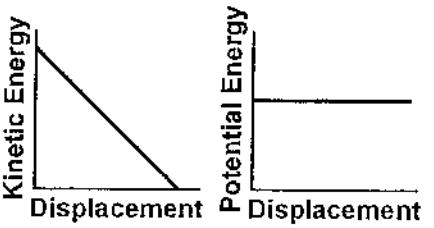
D)


219) An object is thrown vertically upward. Which pair of graphs *best* represents the object's kinetic energy and gravitational potential energy as functions of its displacement while it rises?

A)


B)


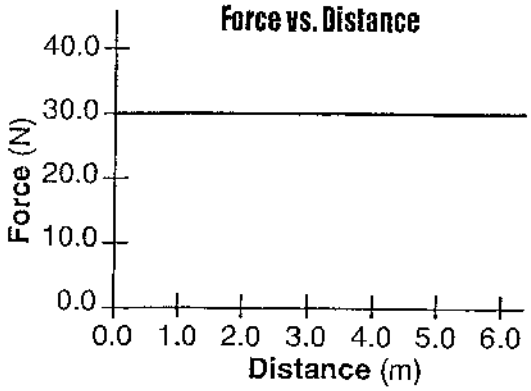
C)


D)


220) As a block slides across a table, its speed decreases while its temperature increases. Which of the following two changes occur in the block's energy as it slides?

A) a decrease in kinetic energy and an increase in internal energy
B) an increase in kinetic energy and a decrease in internal energy
C) a decrease in both kinetic energy and internal energy
D) an increase in both kinetic energy and internal energy

221) A boy pushes his wagon at constant speed along a level sidewalk. The graph below represents the relationship between the horizontal force exerted by the boy and the distance the wagon moves.



As the boy in the given situation pushes the wagon, what happens to the wagon's energy?

A) Internal energy increases.
B) Gravitational potential energy increases.
C) Gravitational potential energy decreases.
D) Internal energy decreases.

222) As a box is pushed 30. meters across a horizontal floor by a constant horizontal force of 25 newtons, the kinetic energy of the box increases by 300. joules. How much total internal energy is produced during this process?

A) 450 J
B) 150 J
C) 250 J
D) 750 J

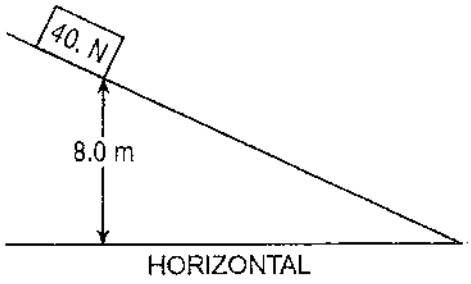
223) As a ball falls freely toward the ground, its total mechanical energy

A) remains the same
B) decreases
C) increases

224) Which one of the following statements describes the kinetic energy and total mechanical energy of a block as it is pulled at constant speed up an incline?

A) Kinetic energy remains the same and total mechanical energy increases.
B) Kinetic energy decreases and total mechanical energy increases.
C) Kinetic energy decreases and total mechanical energy remains the same.
D) Kinetic energy remains the same and total mechanical energy remains the same.

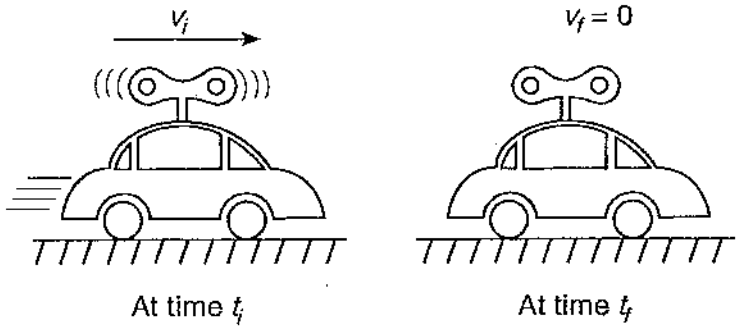
225) A block weighing 40. newtons is released from rest on an incline 8.0 meters above the horizontal, as shown in the diagram below.



If 50. joules of heat is generated as the block slides down the incline, what is the maximum kinetic energy of the block at the bottom of the incline?

A) 270 J B) 50. J C) 320 J D) 3,100 J

226) A wound spring provides the energy to propel a toy car across a level floor. At time t_i, the car is moving at speed v_i across the floor and the spring is unwinding, as shown below. At time t_f, the spring has fully unwound and the car has coasted to a stop.



Which one of the following statements *best* describes the transformation of energy that occurs between times t_i and t_f?

A) Both elastic potential energy and kinetic energy at t_i are converted to internal energy at t_f.

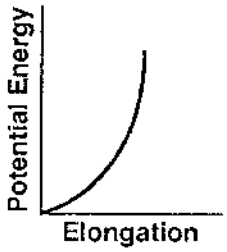
B) Gravitational potential energy at t_i is converted to internal energy at t_f.

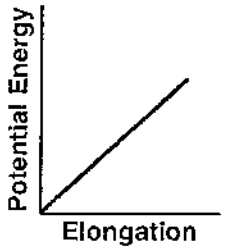
C) Elastic potential energy at t_i is converted to kinetic energy at t_f.

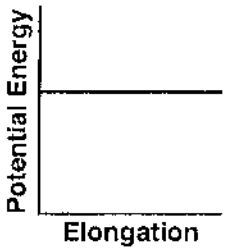
D) Both kinetic energy and internal energy at t_i are converted to elastic potential energy at t_f.

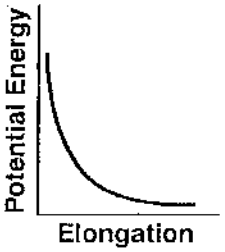
PART 3: ENERGY IN A SPRING

227) Which graph *best* represents the relationship between the elastic potential energy stored in a spring and its elongation from equilibrium?

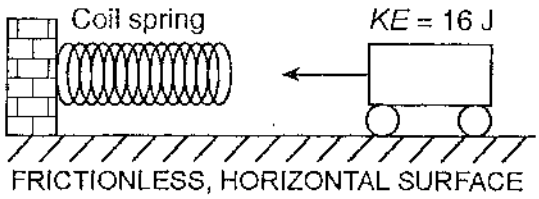
A)


B)


C)


D)


228) The diagram below shows a toy cart possessing 16 joules of kinetic energy traveling on a frictionless, horizontal surface toward a horizontal spring.



If the cart comes to rest after compressing the spring a distance of 1.0 meter, what is the spring constant of the spring?

A) 32 N/m
B) 16 N/m
C) 8.0 N/m
D) 4.0 N/m

229) A spring with a spring constant of 80. newtons per meter is displaced 0.30 meter from its equilibrium position. What is the potential energy stored in the spring?

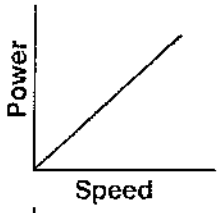
A) 3.6 J
B) 7.2 J
C) 12 J
D) 24 J

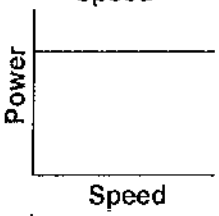
TOPIC C: *Power*

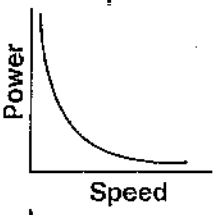
230) What quantity is a measure of the rate at which work is done?

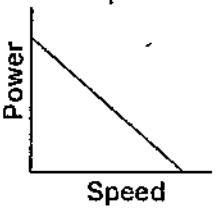
A) power
B) energy
C) momentum
D) velocity

231) Which of the following graphs *best* represents the relationship between the power required to raise an elevator and the speed at which the elevator rises?

A) 

B) 

C) 

D) 

232) Student *A* lifts a 50.-newton box from the floor to a height of 0.40 meter in 2.0 seconds. Student *B* lifts a 40.-newton box from the floor to a height of 0.50 meter in 1.0 second. Compared to student *A*, student *B* does

A) the same work but develops more power
B) the same work but develops less power
C) more work but develops less power
D) less work but develops more power

233) A 110-kilogram bodybuilder and his 55-kilogram friend run up identical flights of stairs. The bodybuilder reaches the top in 4.0 seconds while his friend takes 2.0 seconds. Compared to the power developed by the bodybuilder while running up the stairs, the power developed by his friend is

A) the same
B) twice as much
C) half as much
D) four times as much

234) What is the average power required to raise a 1.81×10^4-newton elevator 12.0 meters in 22.5 seconds?

A) 9.65×10^3 W
B) 8.04×10^2 W
C) 2.17×10^5 W
D) 4.89×10^6 W

235) A small electric motor is used to lift a 0.50-kilogram mass at constant speed. If the mass is lifted a vertical distance of 1.5 meters in 5.0 seconds, the average power developed by the motor is

A) 1.5 W
B) 0.15 W
C) 3.8 W
D) 7.5 W

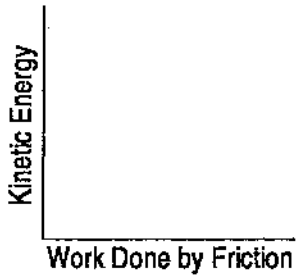
236) What is the power output of an electric motor that lifts a 2.0-kilogram block 15 meters vertically in 6.0 seconds?

A) 49 W
B) 5.0 J
C) 5.0 W
D) 49 J

TOPIC D: *Constructed Response Questions*

❶ PART 1: Work

237) A car, initially traveling at 30. meters per second, slows uniformly as it skids to a stop after the brakes are applied. On the axes provided below, sketch a graph showing the relationship between the kinetic energy of the car as it is being brought to a stop and the work done by friction in stopping the car.



❷ PART 2: Energy

238) A box at the top of a rough incline possesses 981 joules more gravitational potential energy than it does at the bottom. As the box slides to the bottom of the incline, 245 joules of heat is produced. Determine the kinetic energy of the box at the bottom of the incline.

239) Calculate the kinetic energy of a particle with a mass of 3.34×10^{-27} kilogram and a speed of 2.89×10^{5} meters per second. [*Show all work, including the equation and substitution with units.*]

240) A 75-kilogram athlete jogs 1.8 kilometers along a straight road in 1.2×10^{3} seconds.

(a) Determine the average speed of the athlete in meters per second.

(b) Calculate the average kinetic energy of the given athlete. [*Show all work, including the equation and substitution with units.*]

241) A book sliding across a horizontal tabletop slows until it comes to rest. Describe what change, if any, occurs in the book's kinetic energy and internal energy as it slows.

242) A student makes a simple pendulum by attaching a mass to the free end of a 1.50-meter length of string suspended from the ceiling of her physics classroom. She pulls the mass up to her chin and releases it from rest, allowing the pendulum to swing in its curved path. Her classmates are surprised that the mass doesn't reach her chin on the return swing, even though she does not move. Explain why the mass does *not* have enough energy to return to its starting position and hit the girl on the chin.

243) A 65-kilogram pole vaulter wishes to vault to a height of 5.5 meters.

(a) Calculate the *minimum* amount of kinetic energy the vaulter needs to reach this height if air friction is neglected and all the vaulting energy is derived from kinetic energy. [*Show all work, including the equation and substitution with units.*]

(b) Calculate the speed the given vaulter must attain to have the necessary kinetic energy. [*Show all work, including the equation and substitution with units.*]

Questions 244 and 245 refer to the following:

A roller coaster car has a mass of 290. kilograms. Starting from rest, the car acquires 3.13×10^{5} joules of kinetic energy as it descends to the bottom of a hill in 5.3 seconds.

244) Calculate the height of the hill in the situation described. [*Neglect friction.*] [*Show all work, including the equation and substitution with units.*]

245) (a) Calculate the speed of the roller coaster car at the bottom of the hill in the situation described. [*Show all work, including the equation and substitution with units.*]

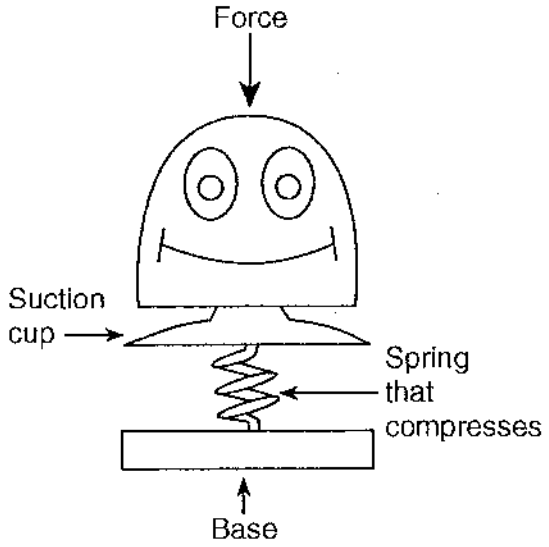
(b) Calculate the magnitude of the average acceleration of the roller coaster car as it descends to the bottom of the hill. [*Show all work, including the equation and substitution with units.*]

246) A vertically hung spring has a spring constant of 150. newtons per meter. A 2.00-kilogram mass is suspended from the spring and allowed to come to rest.

(a) Calculate the elongation of the spring produced by the suspended 2.00-kilogram mass. [*Show all work, including the equation and substitution with units.*]

(b) Calculate the total elastic potential energy stored in the spring due to the suspended 2.00-kilogram mass. [*Show all work, including the equation and substitution with units.*]

247) A pop-up toy has a mass of 0.020 kilogram and a spring constant of 150 newtons per meter. A force is applied to the toy to compress the spring 0.050 meter.

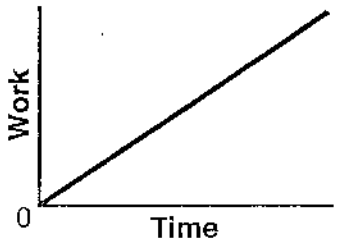


(a) Calculate the potential energy stored in the compressed spring described. [*Show all work, including the equation and substitution with units.*]

(b) The toy is activated and all the compressed spring's potential energy is converted to gravitational potential energy. Calculate the maximum vertical height to which the toy is propelled. [*Show all work, including the equation and substitution with units.*]

❸ PART 3: POWER

248) The graph below represents the relationship between the work done by a person and time.



Identify the physical quantity represented by the slope of the graph.