CONSERVATION OF ENERGY

5. Write an equation for the relationship between the initial and final momentum of the system. Because momentum must be conserved, the initial momentum of the system, which is zero, must equal the final momentum.

$p_{before} = p_{after} = 0$

Write this equality in terms of mass and velocity.

$m_A v_A + m_B v_B = 0$

Solve the equation for v_B.

$m_B v_B = -m_A v_A$

$$v_B = -\frac{m_A v_A}{m_B}$$

Substitute known values and solve.

$$v_B = -\frac{(1.0\ \text{kg})v_A}{2.0\ \text{kg}}$$

$$v_B = -\frac{1}{2}v_A$$

Recognizing that energy is conserved, write an equation that equates the total initial energy of the system and the total final energy of the system.

$PE_i + KE_i + PE_{s_i} = PE_f + KE_f + PE_{s_f}$

$PE_i = PE_f$, $PE_{s_f} = 0$, and $KE_i = 0$

Thus, because energy is conserved, the final kinetic energy of the two carts equals the initial potential energy of the spring.

$PE_{s_i} = KE_f$

Write an equation in terms of mass and velocity that states this relationship.

$$PE_{s_i} = \frac{1}{2}m_A(v_A)^2 + \frac{1}{2}m_B(v_B)^2$$

Substitute known values and solve for v_A.

$$12\ \text{J} = \frac{1}{2}(1.0\ \text{kg})(v_A)^2 + \frac{1}{2}(2.0\ \text{kg})\left(-\frac{v_A}{2}\right)^2$$

$$12\ \text{J} = (0.50\ \text{kg})(v_A)^2 + (1.0\ \text{kg})\left(\frac{v_A^2}{4}\right)$$

$$12\ \text{J} = (0.75\ \text{kg})v_A^2$$

$$v_A^2 = 16\ \text{J/kg} = 16\ \frac{\text{kg}\cdot\text{m}^2/\text{s}^2}{\text{kg}}$$

$v_A = 4.0\ \text{m/s}$

6. It has already been determined that the speed of cart B is one-half that of cart A, thus

$$\frac{KE_A}{KE_B} = \frac{\frac{1}{2}m_A v_A^2}{\frac{1}{2}m_B v_B^2} = \frac{\frac{1}{2}(1.0\ \text{kg})(4.0\ \text{m/s})^2}{\frac{1}{2}(2.0\ \text{kg})(2.0\ \text{m/s})^2} = \frac{2}{1}$$

Review Questions

Name:

67. As the speed of an object falling toward Earth increases, the gravitational potential energy of the object with respect to Earth

(1) decreases
(2) increases
(3) remains the same

68. At what point in its fall does the kinetic energy of a freely falling object equal its gravitational potential energy with respect to the ground?

(1) at the start of the fall
(2) halfway between the start and the end
(3) at the end of the fall
(4) at all points during the fall

69. A 2.0-kilogram mass falls freely for 10. meters near the surface of Earth. The total kinetic energy gained by the object during its free fall is approximately

(1) 400 J (2) 200 J (3) 100 J (4) 50 J

70. A 20.0-kilogram object falls freely from rest and strikes the ground with 1,962 joules of kinetic energy. Calculate how far above the ground the object was when it was released.

71. A 1.0-kilogram mass gains kinetic energy as it falls freely from rest a vertical distance d. How far would a 2.0-kilogram mass have to fall freely from rest to gain the same amount of kinetic energy?

(1) d (2) $2d$ (3) $\frac{d}{2}$ (4) $\frac{d}{4}$

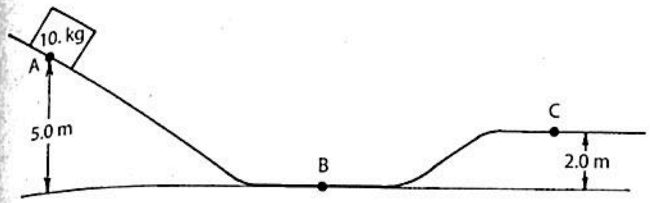
72. A basketball player, who weighs 600 newtons, jumps 0.5 meter vertically off the floor. Calculate her kinetic energy just before hitting the floor.

73. As an object falls freely in a vacuum, the total mechanical energy of the object

(1) decreases
(2) increases
(3) remains the same

Base your answers to questions 74 through 76 on the information and diagram below.

A 10-kilogram block starts from rest at point A and slides along a frictionless track. [Neglect air resistance.]



74. As the block moves from point A to point B, the total amount of gravitational potential energy that changes to kinetic energy is approximately

(1) 5 J (2) 20 J (3) 50 J (4) 500 J

75. What is the approximate speed of the block at point B?

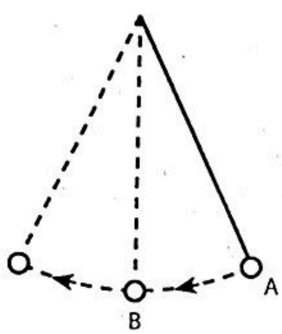
(1) 1 m/s (2) 10 m/s (3) 50 m/s (4) 100 m/s

76. What is the approximate gravitational potential energy of the block at point C?

(1) 20 J (2) 200 J (3) 300 J (4) 500 J

Base your answers to questions 77 and 78 on the information and diagram below.

An ideal simple pendulum is released from rest at position *A* and swings freely through position *B*. [Assume that the gravitational potential energy of the system is zero at *B*.]



77. Compared to the pendulum's kinetic energy at position *B*, its gravitational potential energy at position *A* is

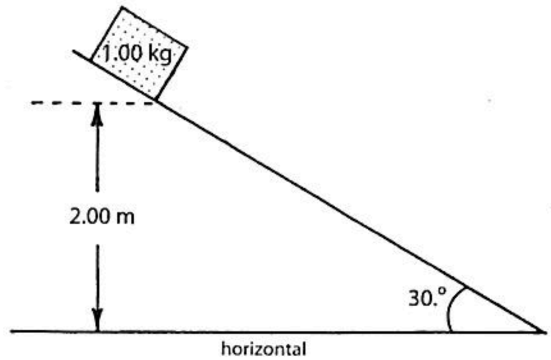
(1) half as great (2) twice as great (3) the same (4) four times as great

78. As the pendulum swings from position *A* to position *B*, the total mechanical energy of the pendulum

(1) decreases (2) increases (3) remains the same

Base your answers to questions 79 through 81 on the information and diagram below.

A 1.00-kilogram block is held at rest on a frictionless plane inclined at 30.° to the horizontal.



79. The block is released and slides down the length of the incline. Determine the block's kinetic energy at the bottom of the incline.

80. If the angle between the plane and the horizontal is increased, the magnitude of the force required to hold the block at rest on the incline will

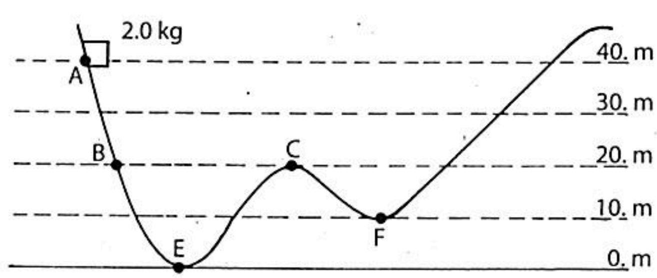
(1) decrease
(2) increase
(3) remain the same

81. As the block slides down the incline, the sum of its gravitational potential energy with respect to the horizontal and kinetic energy

(1) decreases
(2) increases
(3) remains the same

Base your answers to questions 82 through 86 on the information and diagram below.

A 2.0-kilogram block is placed on a frictionless track at point A and released from rest. [Assume that the gravitational potential energy of the system is zero at point E.]



82. Calculate the gravitational potential energy of the system at point A.

83. Compared to the kinetic energy of the block at point *B*, the kinetic energy of the block at point *E* is

(1) the same (3) half as great
(2) twice as great (4) four times as great

84. On the diagram, mark an X on the track to indicate the maximum height the block will reach above point *E* after the block has passed through point *E*.

85. The speed of the block at point *C* is

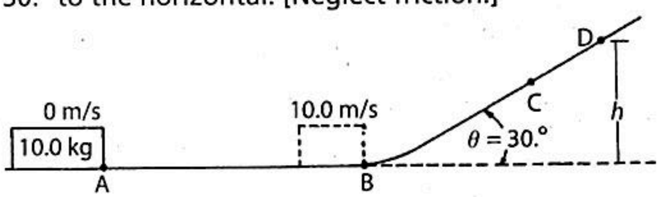
(1) 0 m/s (2) 10. m/s (3) 14 m/s (4) 20. m/s

86. Compared to the total mechanical energy of the system at point *A*, the total mechanical energy of the system at point *F* is

(1) less (2) more (3) the same

Base your answers to questions 87 through 93 on the information and diagram below.

A 10.0-kilogram box starts from rest at point A and is accelerated uniformly to point B in 4.0 seconds by the application of a constant horizontal force *F*. At point *B*, the speed of the box is 10.0 meters per second as it begins to move up a plane inclined at 30.° to the horizontal. [Neglect friction.]



87. Calculate the kinetic energy of the box at point *B*.

88. Calculate the magnitude of force *F*.

89. Calculate the distance the box travels in moving from point *A* to point *B*.

90. Calculate the magnitude of the impulse that would be required to stop the box at point *B*.

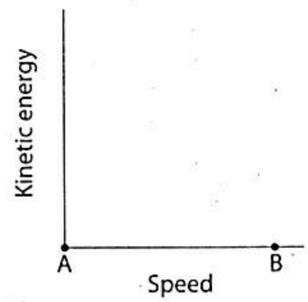
91. As the box moves up the incline, what happens to its speed and gravitational potential energy with respect to $\overline{AB}$?

(1) Both speed and gravitational potential energy decrease.
(2) Speed decreases and gravitational potential energy increases.
(3) Speed remains the same and gravitational potential energy decreases.
(4) Speed remains the same and gravitational potential energy increases.

92. The box comes to rest at a vertical height of *h* (point D) when $\angle\theta = 30.°$. If $\angle\theta$ was increased to 40.°, the box would come to rest at a vertical height

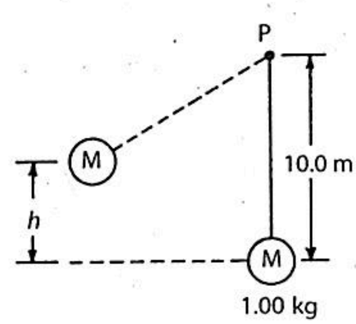
(1) less than *h*
(2) greater than *h*
(3) equal to *h*

93. On the axes below, sketch a line to represent the relationship between the kinetic energy of the box and its speed as it travels from point *A* to point *B*.



Base your answers to questions 94 through 97 on the information and diagram below.

A 1.00-kilogram sphere M, suspended by a string from point P, is lifted to a height *h*. The sphere is released and passes through the lowest point in its swing at a speed of 10.0 meters per second. [Neglect friction.]



94. Calculate the height from which the sphere was released.

95. Calculate the magnitude of the centripetal force on the sphere as it passes through the lowest point in its swing.

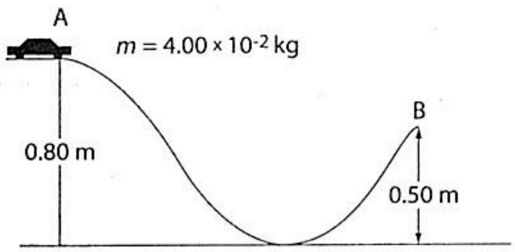
96. The magnitude of the centripetal force on the sphere could be halved as it passes through the lowest point in its swing by doubling the

(1) weight of the sphere, only
(2) length of the string, only
(3) height *h* and the weight of the sphere
(4) the length of the string and height *h*

97. Compared to the sphere's speed through the lowest point of its swing when released from *h*, the sphere's speed through the lowest point when released from 2*h* would be

(1) lower (2) greater (3) the same

98. In the diagram below, a toy car having a mass of 4.00×10^{-2} kilogram starts from rest at point *A* and travels 3.60 meters along a uniform track until coming to rest at point *B*.

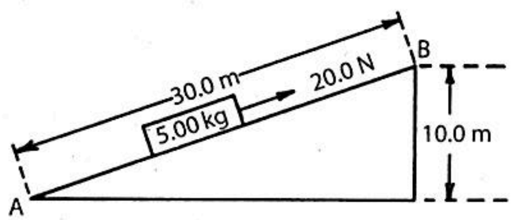


Calculate the magnitude of the frictional force acting on the car. [Assume the frictional force is constant.]

99. A car has a mass of 1.00×10^{3} kilograms. Calculate the work done in moving the car at constant speed a distance of 250 meters along a horizontal asphalt-paved road.

Base your answers to questions 100 and 101 on the information and diagram below.

A 20.0-newton force is needed to pull a 5.00-kilogram object up a hill at a constant speed of 2.0 meters per second.



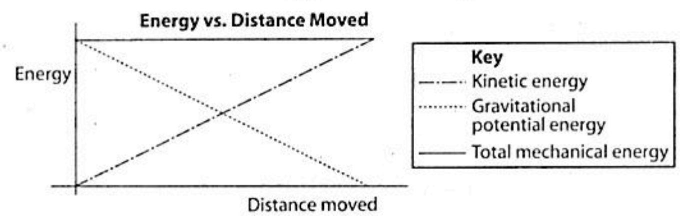
100. Determine the work done against gravity in moving the object from point *A* to point *B*.

101. Determine the work done against friction in moving the object from point *A* to point *B*.

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

(1) a decrease in kinetic energy and an increase in internal energy
(2) an increase in kinetic energy and a decrease in internal energy
(3) a decrease in both kinetic energy and internal energy
(4) an increase in both kinetic energy and internal energy

103. The graph below represents the kinetic energy, gravitational potential energy, and total mechanical energy of a moving block.



Which best describes the motion of the block?

(1) accelerating on a flat horizontal surface
(2) sliding up a frictionless incline
(3) falling freely
(4) being lifted at constant velocity

104. 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?