Conservation Laws

Advanced Placement Physics B
Mr. DiBucci

PROBLEMS

Work Done by a Constant Force

✓1. To push a 52-kg crate across a floor, a worker applies a force of 190 N, directed 22° below the horizontal. As the crate moves 3.3 m, how much work is done on the crate by (*a*) the worker, (*b*) the force of gravity, and (*c*) the normal force of the floor on the crate?

2. A 106-kg object is initially moving in a straight line with a speed of 51.3 m/s. (*a*) If it is brought to a stop with a deceleration of 1.97 m/s^2, what force is required, what distance does the object travel, and how much work is done by the force? (*b*) Answer the same questions if the object's deceleration is 4.82 m/s^2.

✓3. To push a 25-kg crate up a 27° incline, a worker exerts a force of 120 N, parallel to the incline. As the crate slides 3.6 m, how much work is done on the crate by (*a*) the worker, (*b*) the force of gravity, and (*c*) the normal force of the incline?

5. A cord is used to lower vertically a block of mass *M* a distance *d* at a constant downward acceleration of *g*/4. (*a*) Find the work done by the cord on the block. (*b*) Find the work done by the force of gravity.

7. A 52.3-kg trunk is pushed 5.95 m at constant speed up a 28.0° incline by a constant horizontal force. The coefficient of kinetic friction between the trunk and the incline is 0.19. Calculate the work done by (*a*) the applied force and (*b*) the force of gravity.

✓8. A 47.2-kg block of ice slides down an incline 1.62 m long and 0.902 m high. A worker pushes up on the ice parallel to the incline so that it slides down at constant speed. The coefficient of kinetic friction between the ice and the incline is 0.110. Find (*a*) the force exerted by the worker, (*b*) the work done by the worker on the block of ice, and (*c*) the work done by gravity on the ice.

ANSWERS

1) A) 580 J B) ∅ C) ∅

2) A) -208.9 N B) 668 m C) -1.39×10^5 J

3) A) 430 J B) -400 J C) ∅

5) A) $-\frac{3}{4} Mgd$ B) Mgd

7) A) 2160 J B) -1430 J

8) A) 216.5 B) -350. J C) 419 J

The Scalar Product of Two Vectors

12. For **A** = 4**i** + 3**j** and **B** = −**i** + 3**j**, find (a) **A**·**B** and (b) the angle between **A** and **B**.

13. Vector **A** extends from the origin to a point having polar coordinates (7, 70°) and vector **B** extends from the origin to a point having polar coordinates (4, 130°). Find **A**·**B**.

14. Vector **A** has a magnitude of 5.00 units, and **B** has a magnitude of 9.00 units. The two vectors make an angle of 50.0° with each other. Find **A**·**B**.

15. Show that $\mathbf{A}\cdot\mathbf{B} = A_xB_x + A_yB_y + A_zB_z$. (*Hint:* Write **A** and **B** in unit vector form and use Eqs. 7.4 and 7.5.)

16. For **A** = 3**i** + **j** − **k**, **B** = −**i** + 2**j** + 5**k**, and **C** = 2**j** − 3**k**, find **C**·(**A** − **B**).

17. A force **F** = (6**i** − 2**j**) N acts on a particle that undergoes a displacement **s** = (3**i** + **j**) m. Find (a) the work done by the force on the particle and (b) the angle between **F** and **s**.

18. Vector **A** is 2.0 units long and points in the positive *y* direction. Vector **B** has a negative *x* component 5.0 units long, a positive *y* component 3 units long, and no *z* component. Find **A**·**B** and the angle between the vectors.

19. A force **F** = (3.00**i** + 4.00**j**) N acts on a particle. The angle between **F** and the displacement vector **s** is 32.0°, and 100.0 J of work is done by **F**. Find **s**.

20. Find the angle between **A** = −5**i** − 3**j** + 2**k** and **B** = −2**j** − 2**k**.

21. Using the definition of the scalar product, find the angles between (a) **A** = 3**i** − 2**j** and **B** = 4**i** − 4**j**; (b) **A** = −2**i** + 4**j** and **B** = 3**i** − 4**j** + 2**k**; (c) **A** = **i** − 2**j** + 2**k** and **B** = 3**j** + 4**k**.

12) 5, 71.6°
13) 14
14) 28.9

15) $\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$

16) 16.0
17) 36.9°
18) 6, 59.0°
19) $\vec{S} = 2\hat{i} + 23.5\hat{j}$
$\vec{S} = 22\hat{i} + 4.5\hat{j}$
20) 2, 83.4°
21) 11.3°
156°
82.3°

Work Done by a Varying Force

23. A particle is subject to a force F_x that varies with position as in Figure P7.23. Find the work done by the force on the body as it moves (a) from $x = 0$ to $x = 5.0$ m, (b) from $x = 5.0$ m to $x = 10$ m, and (c) from $x = 10$ m to $x = 15$ m. (d) What is the total work done by the force over the distance $x = 0$ to $x = 15$ m?

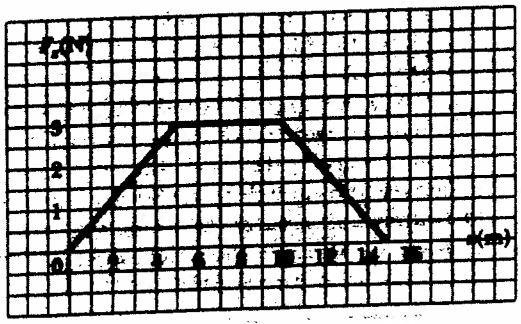


FIGURE P7.23

24. The force acting on a particle varies as in Figure P7.24. Find the work done by the force as the particle moves (a) from $x = 0$ to $x = 8.0$ m, (b) from $x = 8.0$ m to $x = 10$ m, and (c) from $x = 0$ to $x = 10$ m.

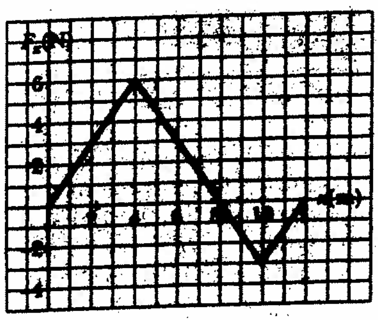


FIGURE P7.24

25. An archer pulls her bow string back 0.400 m by exerting a force that increases uniformly from zero to 230 N. (a) What is the equivalent spring constant of the bow? (b) How much work is done in pulling the bow?

27. A 6000-kg freight car rolls along rails with negligible friction. The car is brought to rest by a combination of two coiled springs, as illustrated in Figure P7.27. Both springs obey Hooke's law, with $k_1 = 1600$ N/m and $k_2 = 3400$ N/m. After the first spring compresses a distance of 30.0 cm, the second spring (acting with the first) increases the force so that there is additional compression, as shown in the graph. If the car is brought to rest 50.0 cm after first contacting the two-spring system, find the car's initial speed.

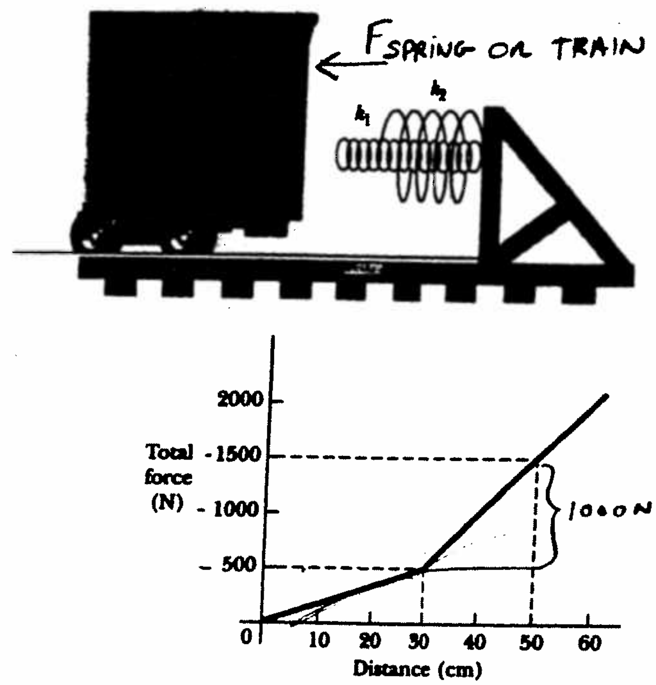


FIGURE P7.27

30). The force required to stretch a Hooke's-law spring varies from zero to 50.0 N as we stretch the spring by moving one end 12.0 cm from its unstressed position. (a) Find the force constant of the spring. (b) Find the work done in stretching the spring.

31. If it takes 4.00 [illegible]'s-law spring 10.0 cm [illegible], determine the extra work required to stretch it an additional 10.0 cm.

23) 7.5J, 15J, 7.5J, 30.J
24) 24J, -3.0J, 21J
25) 575 N/m, 46J
?) 0.299 m/s
28) 10.0 kJ
30) 417 N/m, 3J
31) 12.0 J

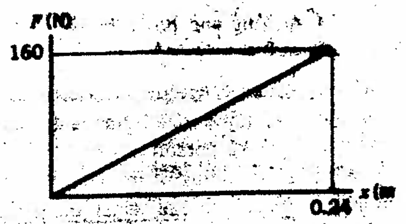
The Ideal SPRING, AND ENERGY CONSERVATION WITH SPRINGS

DiBucci

Section 10.3 The Ideal Spring

23. A spring has a spring constant of 248 N/m. Find the magnitude of the force needed (a) to stretch the spring by 3.00×10^{-2} m from its unstrained length and (b) to compress the spring by the same amount.

24. The graph shows the force F that an archer applies to the string of a long bow versus the string's displacement x. Drawing



back this bow is analogous to stretching a spring. From the data in the graph determine the effective spring constant of the bow.

25. ssm A hand exerciser utilizes a coiled spring. A force of 89.0 N is required to compress the spring by 0.0191 m. Determine the force needed to compress the spring by 0.0508 m.

26. In an exercise apparatus, a spring stretches 0.24 m when a bodybuilder exerts a force of 410 N. When used vertically to support a 12-kg object, by how much does this spring compress?

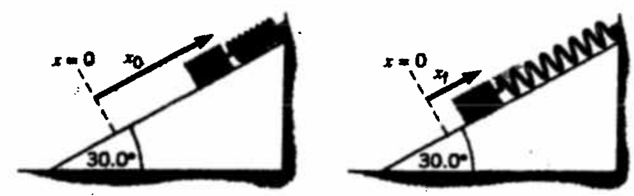
27. In a room that is 2.44 m high, a spring (unstrained length = 0.30 m) hangs from the ceiling. From this spring a board hangs, so that its 1.98-m length is perpendicular to the floor, the lower end just extending the bit not touching the floor. The board weighs 102 N. What is the spring constant of the spring?

50. The spring constant for a spring in a dart gun is 1400 N/m. When the gun is cocked, the spring is compressed by 0.075 m. What is the speed of a 2.4×10^{-2}-kg dart when it leaves the gun horizontally?

51. In preparation for shooting a ball in a pinball machine, a spring ($k = 675$ N/m) is compressed by 0.0650 m relative to its unstrained length. The ball ($m = 0.0585$ kg) is at rest against the spring at point A. When the spring is released, the ball slides (without rolling) to point B, which is 0.300 m higher than point A. How fast is the ball moving at B?

52. A rifle fires a 2.10×10^{-2}-kg pellet straight upward, because the pellet rests on a compressed spring that is released when the trigger is pulled. The spring has a negligible mass and is compressed by 9.10×10^{-2} m from its unstrained length. The pellet rises to a height of 6.10 m above its position on the compressed spring. Ignoring air resistance, determine the spring constant.

54. The drawing shows a block ($m = 1.7$ kg) and a spring ($k = 310$ N/m) on a frictionless incline. The spring is compressed by $x_0 = 0.31$ m relative to its unstrained position at $x = 0$ and then released. What is the speed of the block when the spring is still compressed by $x_f = 0.14$ m?



Section 10.5 Energy

47. An archer pulls the bowstring back for a distance of 0.470 m before releasing the arrow. The bow and string act like a spring whose spring constant is 425 N/m. (a) What is the elastic potential energy of the drawn bow? (b) The arrow has a mass of 0.0300 kg. How fast is it traveling when it leaves the bow?

48. A horizontal spring ($k = 360$ N/m) is lying on a frictionless surface. One end of the spring is attached to a wall, and the other end is connected to an object of mass 2.8 kg. The spring is then compressed by 0.065 m and released from rest. What is the speed of the object at the instant when the spring is *stretched* by 0.048 m relative to its unstrained length?

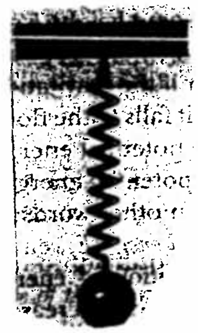
47) 46.9 J, 55.9 m/s
48) 0.5 m/s
50) 18 m/s
51) 6.55 m/s
52) 303 N
54) 4 m/s

23) 7.44 N, 7.44 N
24) 6.7×10^2 N/m
25) 237 N
26) 6.9×10^{-2} m
27) 640 N/m

AP Physics B. {Conservation of Energy} DiBucci

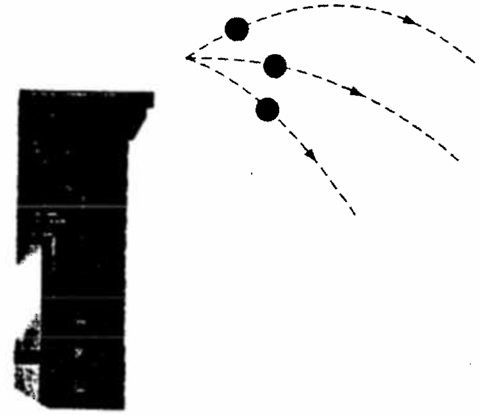
CONCEPTUAL EXAMPLE 8.1

A mass is connected to a massless spring that is suspended vertically from the ceiling as in Figure 8.4. If the mass is displaced downward from its equilibrium position and released, it will oscillate up and down. If air resistance is neglected, will the total mechanical energy of the system (mass plus spring) be conserved? How many forms of potential energy are there for this situation?



CONCEPTUAL EXAMPLE 8.3

Three identical balls are thrown from the top of a building, all with the same initial speed. The first ball is thrown horizontally, the second at some angle above the horizontal, and the third at some angle below the horizontal as in Figure 8.5. Neglecting air resistance, describe their motions and compare the speeds of the balls as they reach the ground.

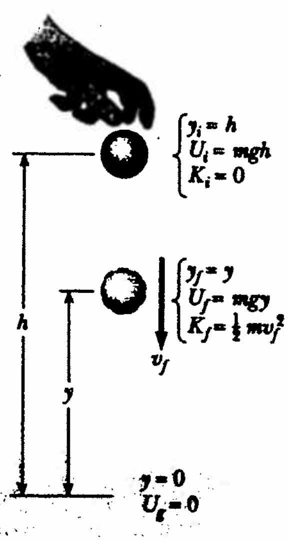


EXAMPLE 8.4 Ball in Free-Fall

A ball of mass m is dropped from a height h above the ground as in Figure 8.6. (a) Neglecting air resistance, determine the speed of the ball when it is at a height y above the ground.

$V_f = \sqrt{2g(h-y)}$

$V_f = \sqrt{V_0^2 + 2g(h-y)}$



EXAMPLE 8.5 The Pendulum

A pendulum consists of a sphere of mass m attached to a light cord of length L as in Figure 8.7. The sphere is released from rest when the cord makes an angle θ_0 with the vertical, and the pivot at P is frictionless. (a) Find the speed of the sphere when it is at the lowest point, b. $V_b = \sqrt{2gL(1-\cos\theta_0)}$

$T_b = mg(3-2\cos\theta_0)$

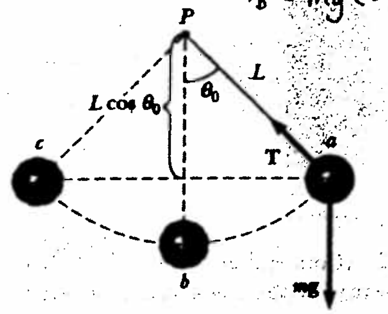


FIGURE 8.7 (Example 8.5) If the sphere is released from rest at the angle θ_0, it will never swing above this position during its motion. At the start of the motion, position a, its energy is entirely potential. This initial potential energy is all transformed into kinetic energy at the lowest elevation, position b. As the sphere continues to move along the arc, the energy again becomes entirely potential energy at position c.

(b) What is the tension T in the cord at b?

EXAMPLE 8.6 Crate Sliding Down a Ramp

A 3.00-kg crate slides down a ramp at a loading dock. The ramp is 1.00 m in length and inclined at an angle of 30.0°, as shown in Figure 8.8. The crate starts from rest at the top, experiences a constant frictional force of magnitude 5.00 N, and continues to move a short distance on the flat floor. Use energy methods to determine the speed of the crate when it reaches the bottom of the ramp. (2.54 m/s)

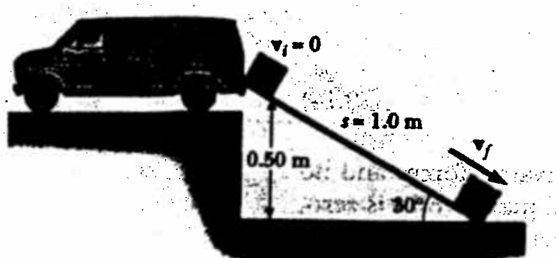


FIGURE 8.8 (Example 8.6) A crate slides down a ramp under the influence of gravity. Its potential energy decreases while its kinetic energy increases.

Exercise Use Newton's second law to find the acceleration of the crate along the ramp and the equations of kinematic to determine the final speed of the crate.

Answer 3.23 m/s²; 2.54 m/s.

Exercise If the ramp is assumed to be frictionless, find th final speed of the crate and its acceleration along the ramp

Answer 3.13 m/s; 4.90 m/s².

EXAMPLE 8.7 Motion on a Curved Track

A child of mass m takes a ride on an irregularly curved slide of height $h = 6.00$ m, as in Figure 8.9. The child starts from rest at the top. (a) Determine the speed of the child at the bottom, assuming no friction is present.

(b) If a frictional force acts on the child, how much mechanical energy is dissipated by this force? Assume that $v_f = 8.00$ m/s and $m = 20.0$ kg.

a) 10.8 m/s
b) −536 J

FIGURE 8.9 (Example 8.7) If the slide is frictionless, the spee of the child at the bottom depends only on the height of th slide.

XAMPLE 8.8 Let's Go Skiing

A skier starts from rest at the top of a frictionless incline of height 20.0 m as in Figure 8.10. At the bottom of the incline, the skier encounters a horizontal surface where the coefficient of kinetic friction between the skis and snow is 0.210. How far does the skier travel on the horizontal surface before coming to rest? (95.2 m)

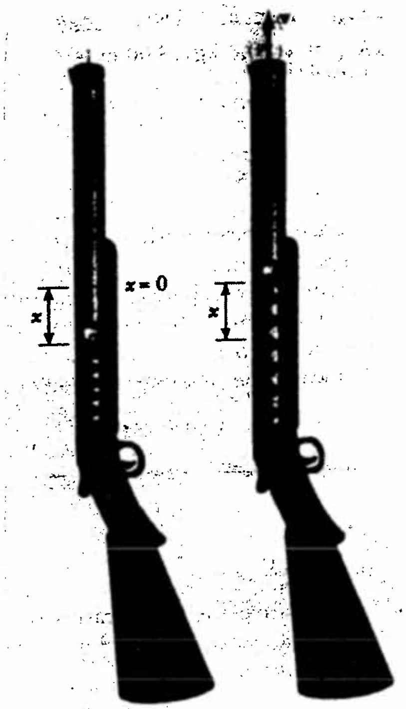
FIGURE 8.10 (Example 8.8).

Exercise Find the horizontal distance the skier travels before coming to rest if the incline also has a coefficient of kinetic friction equal to 0.210.

Answer 40.3 m.

EXAMPLE 8.9 The Spring-Loaded Popgun

The launching mechanism of a toy gun consists of a spring of unknown spring constant (Fig. 8.11a). When the spring is compressed 0.120 m, the gun is able to launch a 35.0-g projectile to a maximum height of 20.0 m when fired vertically from rest. (a) Neglecting all resistive forces, determine the spring constant. a) (953.0 N/m) b) 19.7 m/s



(a) (b)

FIGURE 8.11 (Example 8.9).

(b) Find the speed of the projectile as it moves through the equilibrium position of the spring (where $x = 0$) as shown in Figure 8.11b.

EXAMPLE 8.10 Mass-Spring Collision

A mass of 0.80 kg is given an initial velocity v_i = 1.2 m/s to the right and collides with a light spring of force constant k = 50 N/m, as in Figure 8.12. (a) If the surface is frictionless, calculate the initial maximum compression of the spring after the collision. 0.15 m

(b) If a constant force of friction acts between block [illegible] surface with μ = 0.50 and if the speed of the block just [illegible] collides with the spring is v_i = 1.2 m/s, what is the maximum compression in the spring? X = 0.092 m, −0.25 m

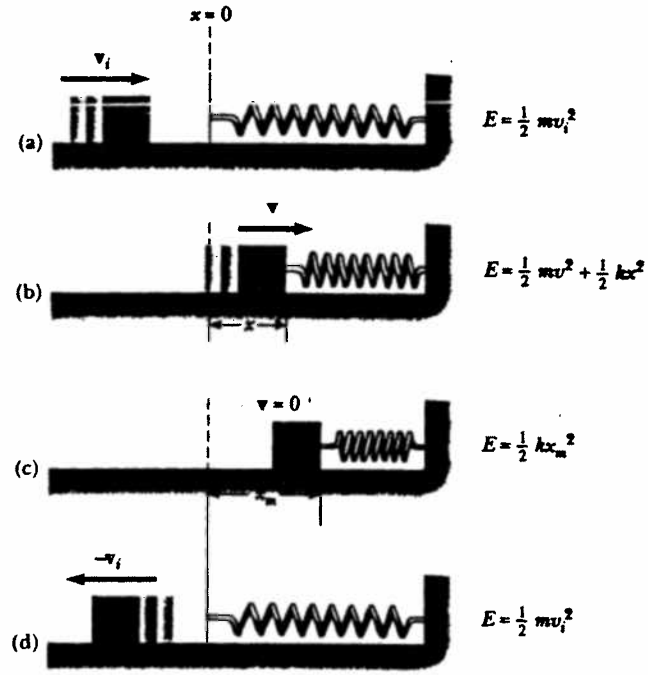


FIGURE 8.12 (Example 8.10) A block sliding on a smooth, horizontal surface collides with a light spring. (a) Initially the mechanical energy is all kinetic energy. (b) The mechanical energy is the sum of the kinetic energy of the block and the elastic potential energy in the spring. (c) The energy is entirely potential energy. (d) The energy is transformed back to the kinetic energy of the block. The total energy remains constant throughout the motion.

EXAMPLE 8.11 Connected Blocks in Motion

Two blocks are connected by a light string that passes over a frictionless pulley as in Figure 8.13. The block of mass m_1 lies on a horizontal surface and is connected to a spring of force constant k. The system is released from rest when the spring is unstretched. If m_2 falls a distance h before coming to rest, calculate the coefficient of kinetic friction between m_1 and the surface.

$$\mu = \frac{m_2 g - \frac{1}{2}kh}{m_1 g}$$

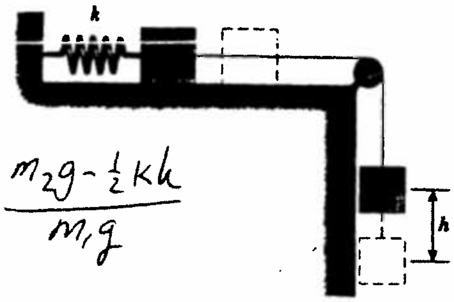


FIGURE 8.13 (Example 8.11) As m_2 moves from its highest elevation to its lowest, the system loses gravitational potential energy but gains elastic potential energy in the spring. Some mechanical energy is lost because of friction between m_1 and the surface.

EXAMPLE 8.12 One Way to Lift an Object

Two blocks are connected by a massless cord that passes over a frictionless pulley and a frictionless peg as in Figure 8.14. One end of the cord is attached to a mass $m_1 = 3.00$ kg that is a distance $R = 1.20$ m from the peg. The other end of the cord is connected to a block of mass $m_2 = 6.00$ kg resting on a table. From what angle θ (measured from the vertical) must the 3.00-kg mass be released in order to just begin to lift the 6.00-kg block off the table? $\theta = 60°$

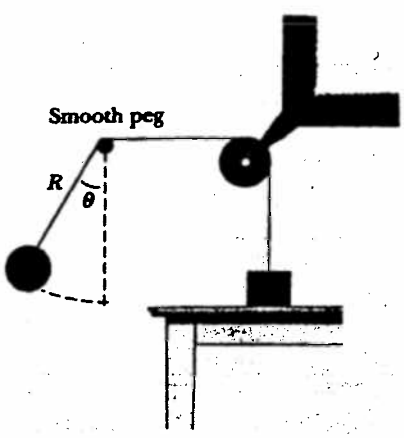


FIGURE 8.14 Example 8.12.

Exercise If the initial angle is $\theta = 40.0°$, find the speed of the 3.00-kg mass and the tension in the cord when the 3.00-kg mass is at the bottom of its circular path.

Answer 2.35 m/s; 43.2 N.

Conservative Forces and Potential Energy
Conservation of Energy

6. A 4.0-kg particle moves along the x axis under the influence of a single conservative force. If the work done on the particle is 80.0 J as it moves from the point $x = 2.0$ m to $x = 5.0$ m, find (a) the change in its kinetic energy, (b) the change in its potential energy, and (c) its speed at $x = 5.0$ m if it starts at rest at $x = 2.0$ m.

[7.] A single conservative force $F_x = (2.0x + 4.0)$ N acts on a 5.0-kg particle, where x is in meters. As the particle moves along the x axis from $x = 1.0$ m to $x = 5.0$ m, calculate (a) the work done by this force, (b) the change in the potential energy of the particle, and (c) its kinetic energy at $x = 5.0$ m if its speed at $x = 1.0$ m is 3.0 m/s.

8. At time t_i, the kinetic energy of a particle is 30 J and its potential energy is 10 J. At some later time t_f, its kinetic energy is 18 J. (a) If only conservative forces act on the particle, what are its potential energy and its total energy at time t_f? (b) If the potential energy at time t_f is 5 J, are there any nonconservative forces acting on the particle? Explain.

[9.] A single constant force $\mathbf{F} = (3.0\mathbf{i} + 5.0\mathbf{j})$ N acts on a 4.0-kg particle. (a) Calculate the work done by this force if the particle moves from the origin to the point having the vector position $\mathbf{r} = (2.0\mathbf{i} - 3.0\mathbf{j})$ m. Does this result depend on the path? Explain. (b) What is the speed of the particle at $\mathbf{r}$ if its speed at the origin is 4.0 m/s? (c) What is the change in its potential energy?

10. A 5.0-kg mass is attached to a light cord that passes over a massless, frictionless pulley. The other end of the cord is attached to a 3.5-kg mass as in Figure P8.10. Use conservation of energy to determine the final speed of the 5.0-kg mass after it has fallen (starting from rest) 2.5 m.

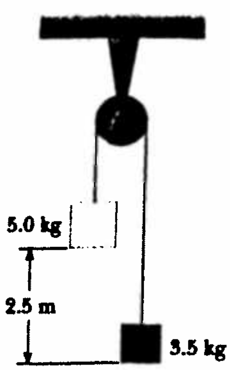


FIGURE P8.10

[11.] A bead slides without friction around a loop-the-loop (Fig. P8.11). If the bead is released from a height $h = 3.50R$, what is its speed at point A? How large is the normal force on it if its mass is 5.00 g?

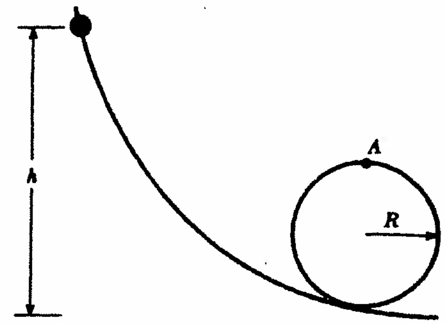


FIGURE P8.11

12. A particle of mass 0.500 kg is shot from P as shown in Figure P8.12 with an initial velocity $\mathbf{v}_0$ having a horizontal component of 30.0 m/s. The particle rises to a maximum height of 20.0 m above P. Using conservation of energy, determine (a) the vertical component of $\mathbf{v}_0$, (b) the work done by the gravitational force on the particle during its motion from P to B, and (c) the horizontal and the vertical components of the velocity vector when the particle reaches B.

13. A rocket is launched at an angle of 53° to the horizontal from an altitude h with a speed v_0. (a) Use energy methods to find its speed when its altitude is $h/2$. (b) Find the x and y components of velocity when the rocket's altitude is $h/2$, using the fact that $v_x = v_{x0}$ = constant (since $a_x = 0$) and the results to part (a).

6) 6.32 m/s
7) SKIP
8) 22 J, 40 J
9) 3.39 m/s
9 J
10) 2.94 m/s
11) 0.098 N Downward
12) 19.8 m/s
294 J
$\vec{V}_B = 30\,\text{m/s}\,\hat{i} - 39.6\,\text{m/s}\,\hat{j}$

13) $\vec{V} = 0.60 V_0\,\hat{i} + -\left(\sqrt{0.64 V_0^2 + gh}\right)\hat{j}$

Conservative Forces
Continued

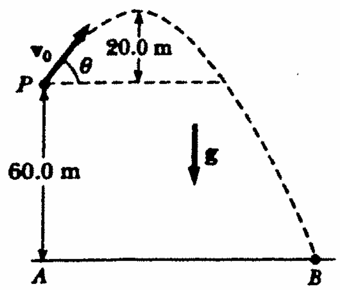


FIGURE P8.12

14. A 1.0-kg ball is attached to a 10-lb (44.5 N) fish line. The ball is released from rest at the horizontal position ($\theta = 90°$). At what angle θ (measured from the vertical), does the line break?
15. A 20.0-kg cannon ball is fired from a cannon at muzzle speed of 1000 m/s and at an angle of 37.0° with the horizontal. A second ball is fired at an angle of 90.0°. Use the conservation of mechanical energy to find, for each ball, (a) the maximum height reached and (b) the total mechanical energy at the maximum height.
16. A ball of mass m is spun in a vertical circle having radius R. The ball has a speed v_0 at its highest point. Take zero potential energy at the lowest point and use the angle θ measured with respect to the vertical as shown in Figure P8.16. (a) Derive an expression for the speed v at any time as a function of R, θ, v_0, and g. (b) What minimum speed v_0 is required to keep the ball moving in a circle? (c) Does the equation you derived in part (a) account for the result found in part (b)? Explain.

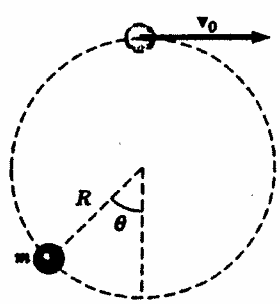


FIGURE P8.16

17. Two masses are connected by a light string passing over a light frictionless pulley as shown in Figure P8.17. The 5.0-kg mass is released from rest. Using the law of conservation of energy, (a) determine the speed of the 3.0-kg mass just as the 5.0-kg mass hits the ground. (b) Find the maximum height to which the 3.0-kg mass rises.

17A. Two masses are connected by a light string passing over a light frictionless pulley as in Figure P8.17. The mass m_1 is released from rest. Using the law of conservation of energy, (a) determine the speed of m_2 just as m_1 hits the ground. (b) Find the maximum height to which m_2 rises.

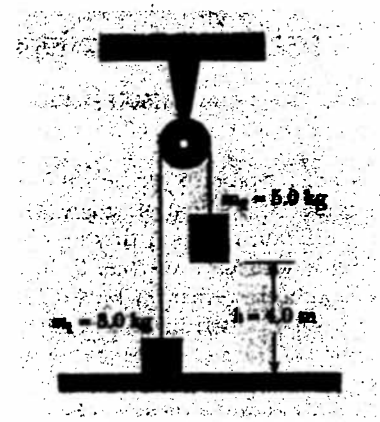


FIGURE P8.17

18. A child slides down the frictionless slide shown in Figure P8.18. In terms of R and H, at what height h will he lose contact with the section of radius R?

FIGURE P8.18

14) 40.8°
15) 1.85×10^4 m
5.1×10^4 m
1×10^7 J
16) $V = \sqrt{V_0^2 + 2gR + 2gR\cos\theta}$
17) 4.43 m/s, 5 m
18) $h = \frac{2}{3} H$
$H \geq 3/2\, R$

Changes in Mechanical Energy When Nonconservative Forces Are Present

19. A 5.0-kg block is set into motion up an inclined plane with an initial speed of 8.0 m/s (Fig. P8.19). The block comes to rest after traveling 3.0 m along the plane, which is inclined at an angle of 30° to the horizontal. Determine (a) the change in the block's kinetic energy, (b) the change in its potential energy, (c) the frictional force exerted on it (assumed to be constant). (d) What is the coefficient of kinetic friction?

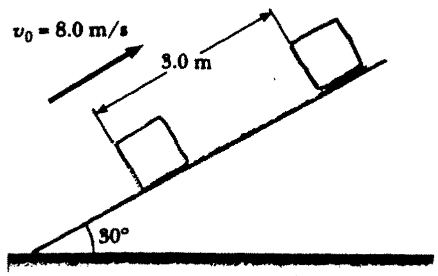


FIGURE P8.19

20 A 3.0-kg block starts at a height $h = 60$ cm on a plane that has an inclination angle of 30° as in Figure P8.20. Upon reaching the bottom, the block slides along a horizontal surface. If the coefficient of friction on both surfaces is $\mu_k = 0.20$, how far does the block slide on the horizontal surface before coming to rest? (*Hint:* Divide the path into two straight-line parts.)

20A A block of mass m starts at a height h on a plane that has an inclination angle θ as in Figure P8.20. Upon reaching the bottom, the block slides along a horizontal surface. If the coefficient of friction on both surfaces is μ_k, how far does the block slide on the horizontal surface before coming to rest? (*Hint:* Divide the path into two straight-line parts.)

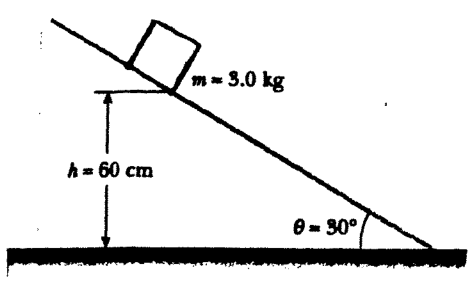


FIGURE P8.20

21. A parachutist of mass 50.0 kg jumps out of an airplane at a height of 1000 m and lands on the ground with a speed of 5.00 m/s. How much energy was lost to air friction during this jump?

22. A 0.500-kg bead slides on a curved wire, starting from rest at point A in Figure P8.22. The segment from A to B is frictionless, and the segment from B to C is rough. (a) Find the speed of the bead at B. (b) If the bead comes to rest at C, find the energy lost due to friction as it moves from B to C.

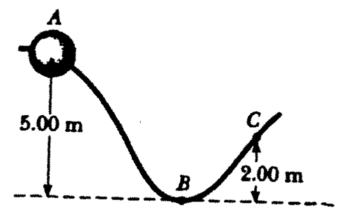


FIGURE P8.22

19) 0.679
20) 1.96m
21) 498kJ
22) −14.7J
23) -4.1×10^6 J
9.97 m/s
50.8 m
24) 24.5 m/s
too FAST
206 m
25) 3.47 m/s
26) 1.40 m/s
27) $y_{max} = h/(1+\mu_k \cot\theta)$
28) 0.381 m
0.143 m
0.371 m
29) 914 N/m
30) 0.344 m
31) −280 J, 0.446 m

Nonconservative Force, Continued

[redacted]

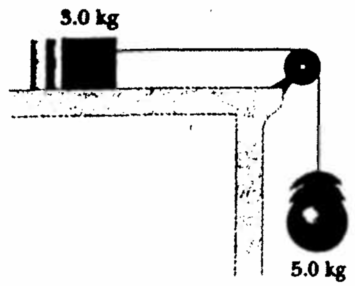


FIGURE P8.25

26. A toy gun uses a spring to project a 5.3-g soft rubber sphere. The spring constant is 8.0 N/m, the barrel of the gun is 15 cm long, and there is a constant frictional force of 0.032 N between barrel and projectile. With what speed is the projectile launched from the barrel if the spring is compressed 5.0 cm?
27. A block slides down a curved frictionless track and then up an inclined plane as in Figure P8.27. The coefficient of kinetic friction between block and incline is μ_k. Use energy methods to show that the maximum height reached by the block is

$$y_{max} = \frac{h}{1 + \mu_k \cot(\theta)}$$

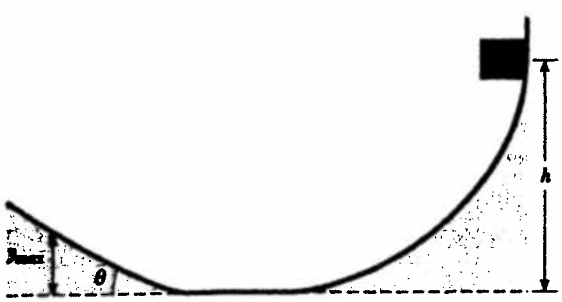


FIGURE P8.27

28. A 1.5-kg mass is first held 1.2 m above a relaxed massless spring that has a spring constant of 320 N/m and then dropped onto the spring. (a) How far does the spring compress? (b) The same experiment is repeated on the Moon, where $g = 1.63$ m/s^2. (c) Repeat part (a), but this time assume that a constant 0.70-N air-resistance acts on the mass during the fall.
29. In the dangerous "sport" of bungee-jumping, a daring student jumps from a balloon with a specially designed elastic cord attached to his ankles. The unstretched length of the cord is 25.0 m, the student weighs 700 N, and the balloon is 36.0 m above the surface of a river. Calculate the required force constant of the cord if the student is to stop safely 4.00 m above the river.

[redacted]

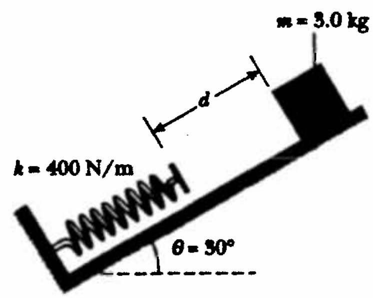


FIGURE P8.30

31. An 8.00-kg block travels on a rough, horizontal surface and collides with a spring as in Figure 8.12. The speed of the block *just before* the collision is 4.00 m/s. As the block rebounds to the left with the spring uncompressed, its speed as it leaves the spring is 3.00 m/s. If the coefficient of kinetic friction between block and surface is 0.400, determine (a) the energy lost due to friction while the block is in contact with the spring and (b) the maximum distance the spring is compressed.

Name ____ Per. ____ Date _____

Linear momentum and its conservation, and impulse

1. A 7.0 kg bowling ball moves in a straight line at 3.0 m/s. How fast must a 2.45 g ping–pong ball move in a straight line so the two balls have the same momentum?

(8571 m/s)

2. A baseball player uses a pitching machine to help him improve his batting average. He places the 50 kg machine on a frozen pond. the machine fires a 0.15 kg baseball horizontally with a speed of 36 m/s in the positive x direction. what is the recoil velocity of the machine?

(0.11 m/s in the negative x direction)

3. In a particular crash test, an automobile of mass 1500 kg collides with a wall. The initial and final velocities of the car are -15.0 m/s and + 2.6 m/s respectively. if the collision lasts for 0.150 s, Calculate the impulse due to the collision and the average force exerted on the automobile.

(+2.64 E+4 N s, 1.76 E+5 N)

4. Explain why a boxer moves his/her head backward just before receiving a punch and how this maneuver helps reduce the force of impact in terms of the impulse momentum theorem .

5. A tennis player receives a shot with the ball (0.060 kg) traveling horizontally at 50 m/s, and she returns the shot with the ball traveling horizontally in the exact opposite direction at 40.0 m/s. Calculate the impulse delivered to the ball by the racket.

(5.40 N s)

Name ____ Per. ___ Date ______
Collisions in one dimension DiBucci

1. Two blocks of mass M and 3M on a horizontal frictionless surface. A spring is attached to one of them and they are pushed together, compressing the spring and held at rest. When released, 3M moves to the right with a speed of 2.00 m/s. What is the speed of the block with Mass M?

(-6 m/s)

2. A 90 kg halfback running north at a speed of 10 m/s is tackled by a 120 kg opponent running south with a speed of 4.0 m/s.

a) calculate the speed and direction of the players just after the tackle
b) determine the energy lost as a result of the collision, and account for the missing energy.

(2.0 m/s north, 5.04 kJ, noise and energy absorbed by the players (bruises and fractures))

3. A 12.0 g bullet is fired into a 100 g block initially at rest on a horizontal surface. After impact the block slides 7.5 meters before coming to rest. If the coefficient of friction between the block and the surface is 0.65, what was the speed of the bullet immediately before impact?

(91.2 m/s)

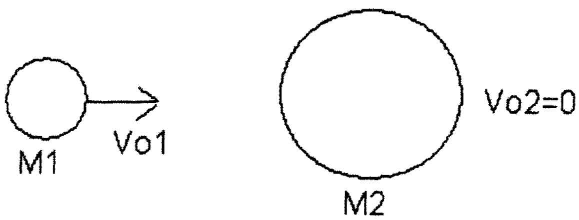
4. A 1200 kg car is traveling initially with a speed of 25.0 m/s in an easterly direction crashes into the rear end if a 9000 kg truck moving in the same direction at 20.0 m/s. The velocity if the car right after the collision is 18 m/s to the east.

a) calculate the velocity of the truck after the collision.
b) calculate how much mechanical energy is lost in the collision.

(20.9 m/s, 8.68 kJ)

Name ______________________________ per. ___ date ____
Conservation of Momentum DiBucci
Collisions in one dimension

1. A ball of mass **M1=0.250kg and an initial velocity Vo1= +5 m/s** makes a **perfectly head on elastic collision** with **M2=0.800 kg which is initially at rest.** See the diagram below. No external forces act on the balls. Calculate the velocities of the balls after the collisions, and the **coefficient of restitution.**



2. Calculate the final velocity of each if it is a **completely inelastic collision (they stick together)**

Name ______________________________ **per.** ___ **date** ____

Conservation of Momentum **DiBucci**

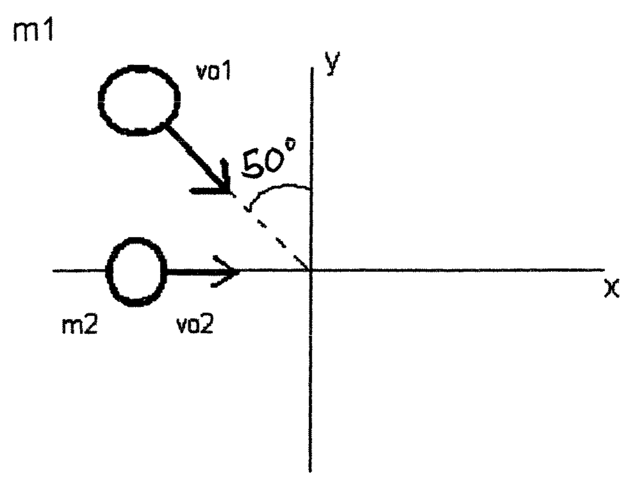
Collisions in Two dimension

1. Consider the **two dimensional inelastic collision** in the diagram below

Data: **m1= 0.150kg, vo1=0.900m/s** **m2= 0.260 kg, vo2=0.540 m/s, and makes a 50 degree angle with the Y**-axis **The final velocity and angle for mass m2:** **Vf2= 0.700 m/s** **Angle = 35 degrees below the positive x axis (south of east)**

a. Calculate the final velocity and angle for mass m1 (Vf1 and its angle with the positive x axis)

b. Calculate the final velocity (magnitude and direction) of each if it is a **completely inelastic collision (They stick together)**



Name ______________________________________ Per. ___ date ________
Collisions in Two Dimensions DiBucci

1. A 1500 kg car traveling east with a speed of 25.0 m/s collides at an intersection with a 2500 kg van traveling north at a speed if 20.0 m/s Find the magnitude and direction of the velocity of the wreckage after the collision, assuming the vehicles undergo a perfectly inelastic collision.

(15.6 m/s, 53.1 degrees north of east)

2. An unstable nucleus if mass 17 E -27 kg initially ay rest disintegrates into three particles. One of the particles of mass 5 E -27 kg moves along the y axis with a speed of 6 E +6 m/s. Another particle of mass 8.4 E -27 kg, moves along the x axis with a speed of 4.0 E +6 m/s.

a) Find the velocity of the third particle
b) calculate the total energy given off in the process

(Vx= -9.33 E 6 m/s, Vy= -8.33 E + 6 m/s, 4.39 E -13 J)

3. A 0.30 kg puck, initially at rest on a horizontal, frictionless surface, is struck by a 0.20 kg puck moving initially along the x axis at a speed of 2.0 m/s. After the collision, the 0.20 kg puck has a speed of 1.0 m/s at an angle of 53 degrees relative to the positive x axis.

a) determine the velocity of the 3.0 kg puck
b) Find the fraction of the kinetic energy lost in the collision.

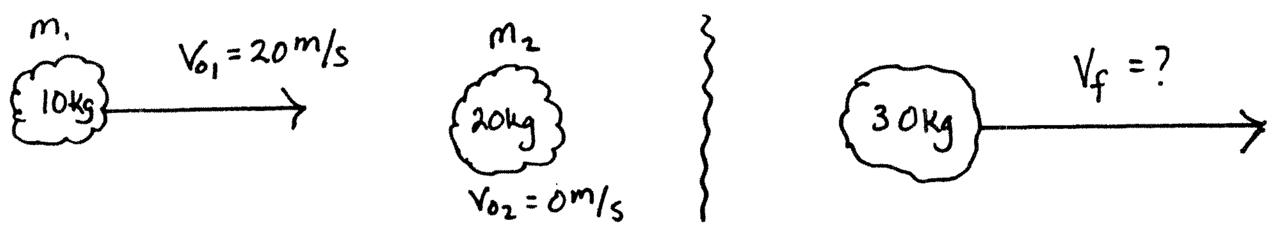
(1.07 m/s , 29.7 degrees, -0.318)

NAME ______________________ PER ________ DIBUCCI

*CALCULATE THE VELOCITY INDICATED, FOR EACH EXAMPLE

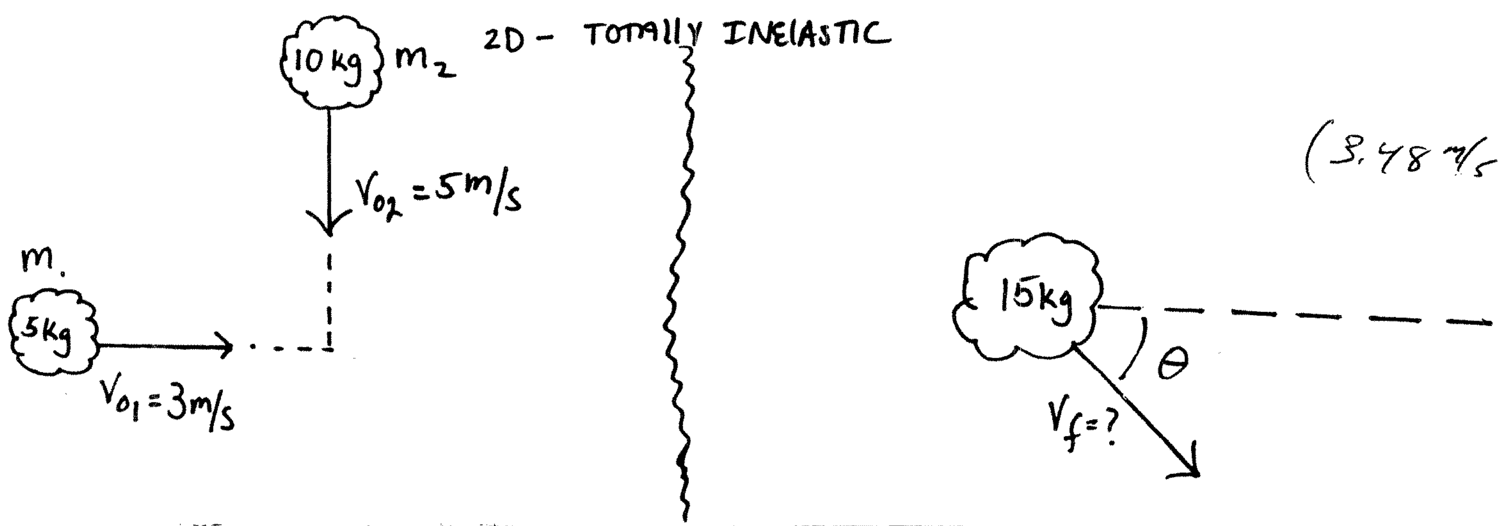
$$m_1\vec{v}_{o1} + m_2\vec{v}_{o2} = m_1\vec{v}_{f1} + m_2\vec{v}_{f2}$$

1.) TOTALLY INELASTIC



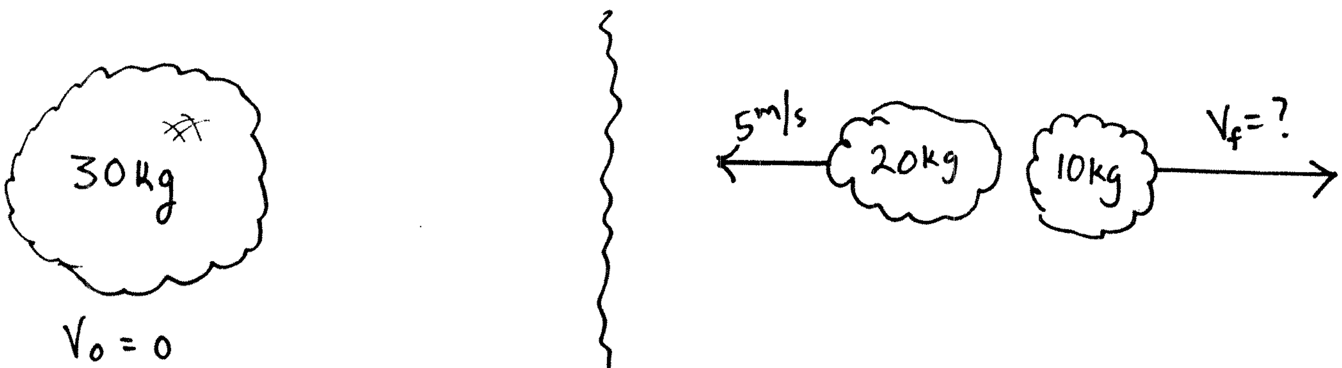
(6.67 m/s)

2.) 2D - TOTALLY INELASTIC



(3.48 m/s @ 73.3°)

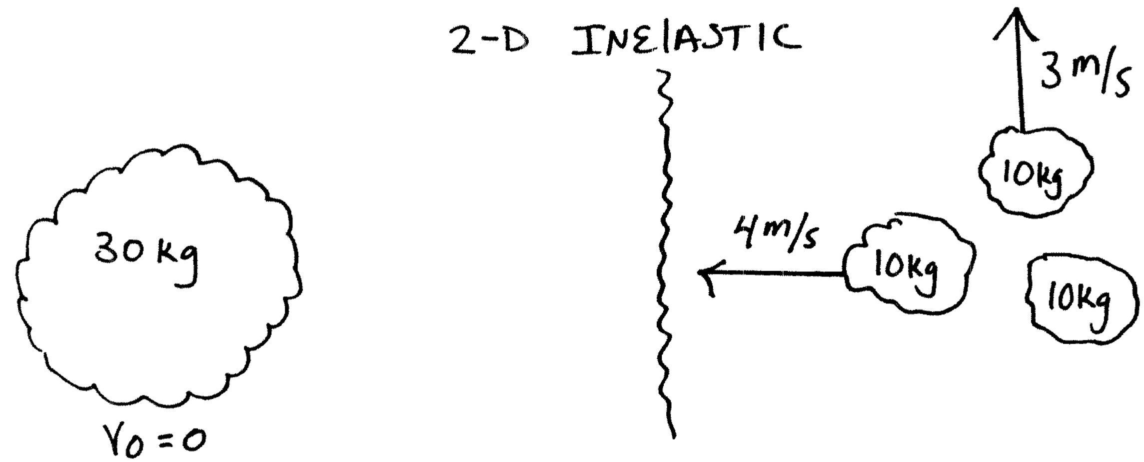
3.) INELASTIC



(10 m/s)

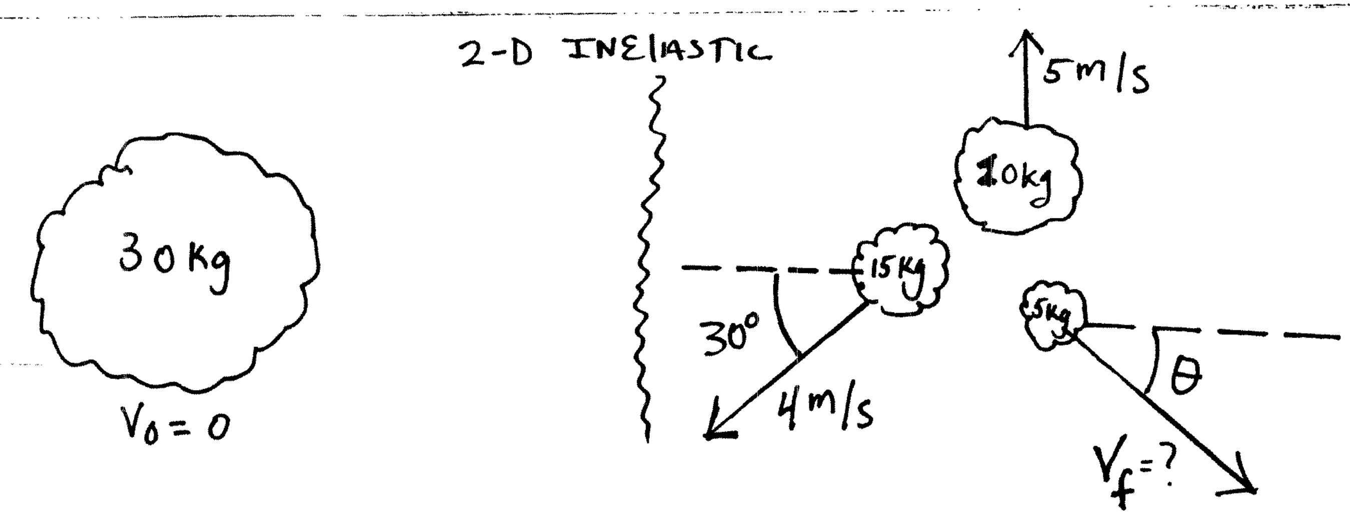
DIBUCCI

4.) 2-D INELASTIC



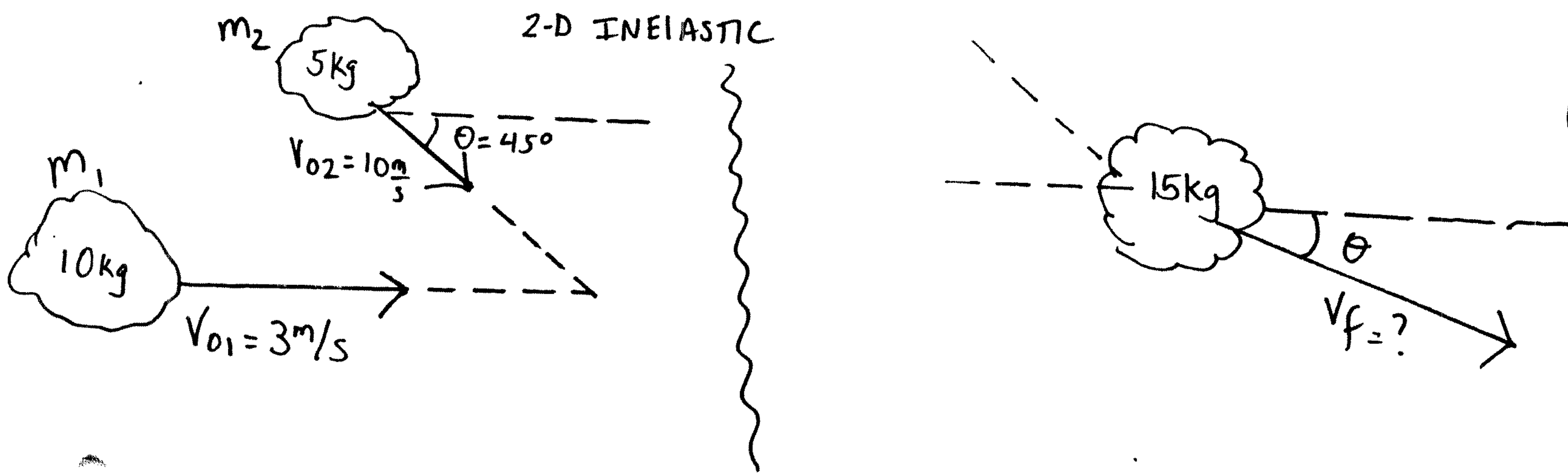
(5 m/s at 36.9° S of E)

5.) 2-D INELASTIC



(11.14 m/s at 21° S of E)

6.) 2-D INELASTIC



(4.9 m/s at 28° S of E)

EXAMPLE 9 • A Ballistic Pendulum

A ballistic pendulum is sometimes used in laboratories to measure the speed of a projectile, such as a bullet. The ballistic pendulum shown in Figure 7.15*a* consists of a block of wood (mass $m_2 = 2.50$ kg) suspended by a wire of negligible mass. A bullet (mass $m_1 = 0.0100$ kg) is fired with a speed v_{01}. Just after the bullet collides with it, the block (with the bullet in it) has a speed v_f and then swings to a maximum height of 0.650 m above the initial position (see part *b* of the drawing). Find the speed of the bullet.

Reasoning The physics of the ballistic pendulum can be divided into two parts. First, there is the completely inelastic collision between the bullet and the block. Second, there is the resulting motion of the block and bullet as they swing upward. The total momentum of the system (block plus bullet) is conserved during the collision, because the suspension wire supports the system's weight, which means that the sum of the external forces acting on the system is nearly zero. Furthermore, as the system swings upward, the principle of conservation of mechanical energy applies, because nonconservative forces do no work. The tension force in the wire does no work because it acts perpendicular to the motion. And air resistance is negligible during the swing.

(896 m/s)

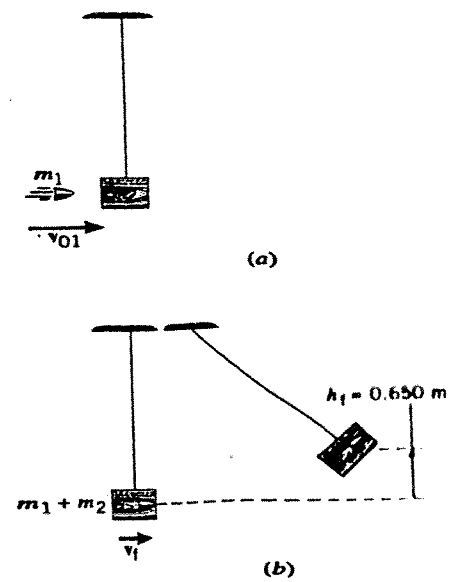
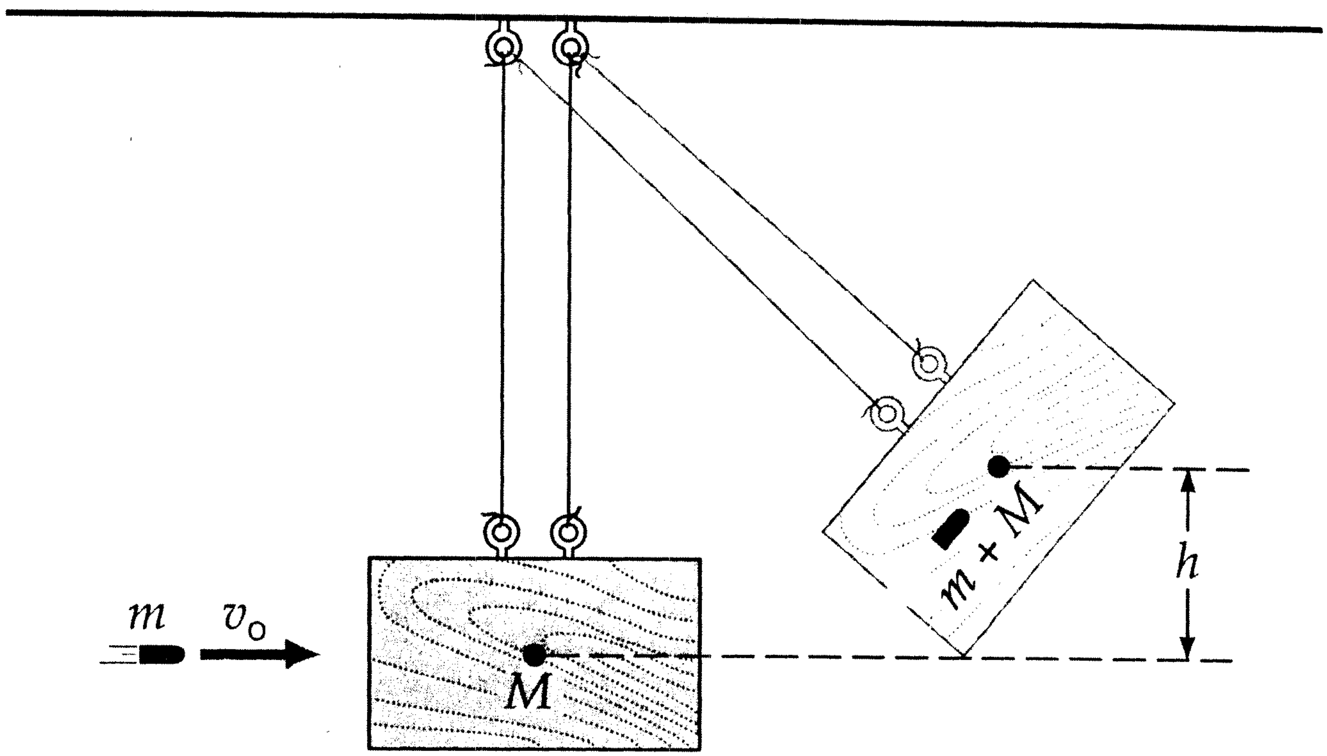


Figure 7.15 (*a*) A bullet approaches a ballistic pendulum. (*b*) The block and bullet swing upward after the collision.

A ballistic pendulum

4. M=2.5 kg, m=0.0010 kg, and the final height of the system is 0.650m. Calculate the initial velocity of the bullet.(896 m/s)
Use the following hyperlink to help you solve the problem.
Ballistic Pendulum



26. A 45-kg swimmer runs with a horizontal velocity of +5.1 m/s off a boat dock into a stationary 12-kg rubber raft. Find the velocity that the swimmer and raft would have after the impact, if there were no friction and resistance due to the water.

27. In a football game, a receiver is standing still, having just caught a pass. Before he can move, a tackler, running at a velocity of +4.5 m/s, grabs him. The tackler holds onto the receiver, and the two move off together with a velocity of +2.6 m/s. The mass of the tackler is 115 kg. Assuming that momentum is conserved, find the mass of the receiver.

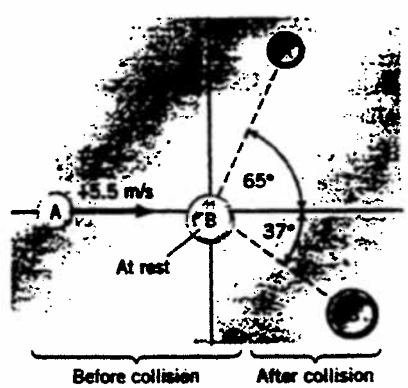
28. A boy is at rest on a skateboard. The total mass of the boy and the skateboard is 30.0 kg. He is at the foot of a hill when he catches a 5.00-kg ball and, as a result, moves up the hill. Just before he catches the ball, it is moving nearly parallel to the ground and has a speed of 10.0 m/s. Ignore the effects of friction and gravity during the short time the ball is being caught. Through what maximum vertical height will the boy coast up the hill?

29. **ssm** A golf ball bounces down a flight of steel stairs, striking each stair once on the way down. The ball starts at the top step with a vertical velocity component of zero. If all the collisions with the stairs are elastic, and if the vertical height of the staircase is 3.00 m, determine the bounce height when the ball reaches the bottom of the stairs. Neglect air resistance.

30. A cue ball (mass = 0.165 kg) is at rest on a frictionless pool table. The ball is hit dead center by a pool stick which applies an impulse of +1.50 N·s to the ball. The ball then slides along the table and makes an elastic head-on collision with a second ball of equal mass that is initially at rest. Find the velocity of the second ball just after it is struck.

31. A 0.150-kg projectile is fired with a velocity of +715 m/s at a 2.00-kg wooden block that rests on a frictionless table. The velocity of the block, immediately after the projectile passes through it, is +40.0 m/s. Find the velocity with which the projectile exits from the block.

32. The drawing shows a collision between two pucks on an air-hockey table. Puck A has a mass of 0.025 kg and is moving along the x axis with a velocity of +5.5 m/s. It makes a collision with puck B, which has a mass of 0.050 kg and is initially at rest. After the collision, the two pucks fly apart with the angles shown in the drawing. Find the final speed of (a) puck A and (b) puck B.



33. **ssm www** A 5.00-kg ball, moving to the right at a velocity of +2.00 m/s on a frictionless table, collides head-on with a stationary 7.50-kg ball. Find the final velocities of the balls if the collision is (a) elastic and (b) completely inelastic.

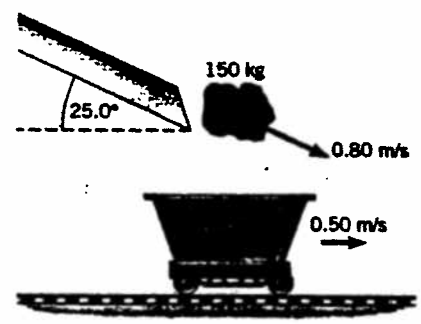
*34. A 60.0-kg person, running horizontally with a velocity of +3.80 m/s, jumps onto a 12.0-kg sled that is initially at rest. (a) Ignoring the effects of friction during the collision, find the velocity of the sled and person as they move away. (b) The sled and person coast 30.0 m on level snow before coming to rest. What is the coefficient of kinetic friction between the sled and the snow?

*35. A 0.010-kg bullet is fired straight up at a falling wooden block that has a mass of 2.0 kg. The bullet has a speed of 750 m/s when it strikes the block. The block originally was dropped from rest from the top of a building and had been falling for a time t when the collision with the bullet occurs. As a result of the collision, the block (with the bullet in it) reverses direction, rises, and comes to a momentary halt at the top of the building. Find the time t.

*36. Three guns are mounted on a circle, 120.0° apart. They are aimed at the center of the circle, and each fires a bullet simultaneously. One bullet has an unknown mass and a speed of 575 m/s. The other two bullets have the same mass of 4.50×10^{-3} kg and the same speed of 324 m/s. The bullets collide at the center and mash into a *stationary* lump. What is the unknown mass?

*37. **ssm** A 50.0-kg skater is traveling due east at a speed of 3.00 m/s. A 70.0-kg skater is moving due south at a speed of 7.00 m/s. They collide and hold on to each other after the collision, managing to move off at an angle θ south of east, with a speed of v_f. Find (a) the angle θ and (b) the speed v_f, assuming that friction can be ignored.

*38. A mine car, whose mass is 440 kg, rolls at a speed of 0.50 m/s on a horizontal track, as the drawing shows. A 150-kg chunk of coal has a speed of 0.80 m/s when it leaves the chute. Determine the velocity of the car/coal system after the coal has come to rest in the car.



37) 73°, 4.28m/s
38) 0.56 m/s, Right

26) 4m/s
27) 84kg
.) 0.104m
29) 3m
30) 9.09 m/s

31) 182 m/s
32) 3.4m/s
2.6m/s
33) -0.4m/s
+1.6m/s
0.8m/s

34) 3.17 m/s, 0.0171
35) 0.19s
36) 2.54×10^{-3} kg

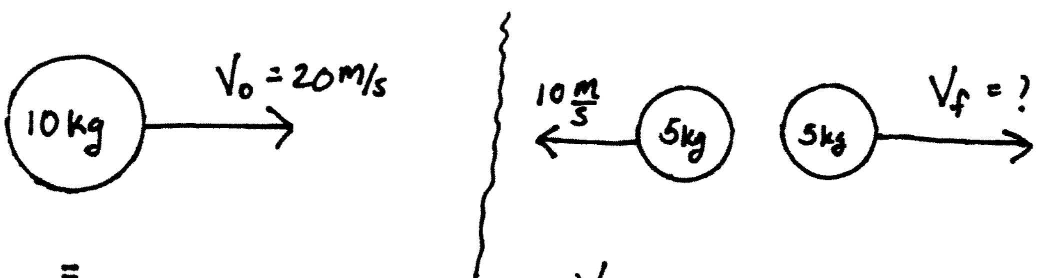
NAME ______________________ Per.____ DATE________

CENTER OF MASS Velocity

DiBucci

Directions: For Each Problem calculate the unknown velocity AND Direction. Also, Verify that the Velocity of the center of mass DOES NOT change

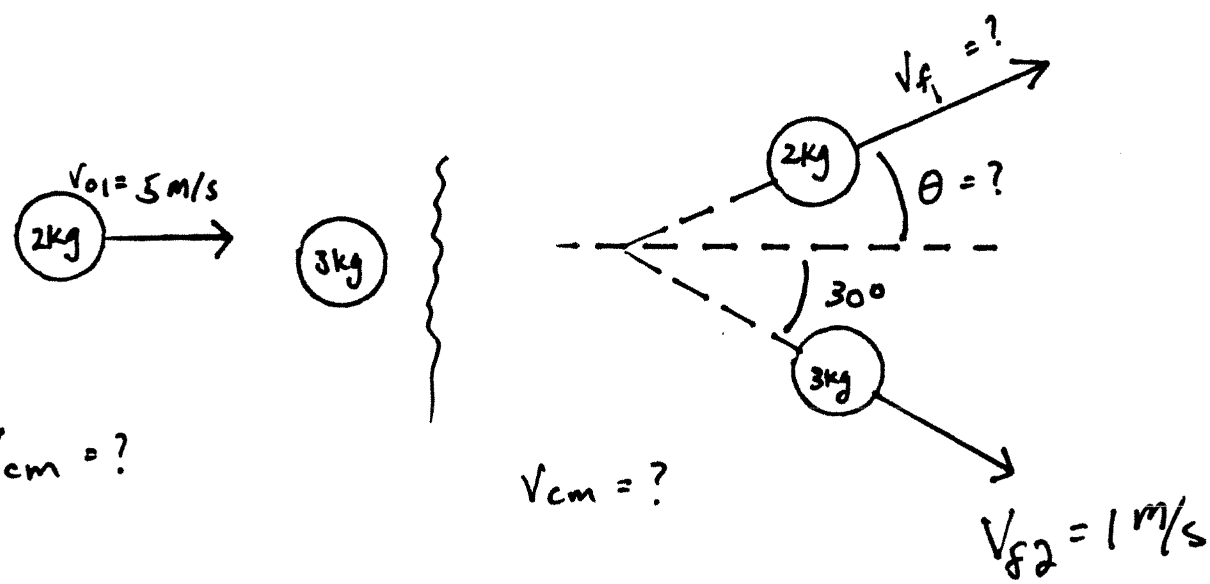
1)



$V_{x_{cm}}$ =

V_{cm} =

2)



V_{cm} = ?

V_{cm} = ?

Relativistic Momentum

AP Physics - B
DiBucci

1. A proton has a mass of 1.673×10^{-27} kg. If the proton is accelerated to a speed of $0.93c$, what is the magnitude of the relativistic momentum of the proton?

A) 6.2×10^{-17} kg • m/s
B) 1.3×10^{-18} kg • m/s
C) 4.7×10^{-19} kg • m/s
D) 5.9×10^{-24} kg • m/s
E) 1.6×10^{-27} kg • m/s

2. The momentum of an electron is 1.60 times larger than the value computed non-relativistically. What is the speed of the electron?

A) 2.94×10^{8} m/s
B) 2.76×10^{8} m/s
C) 2.61×10^{8} m/s
D) 2.34×10^{8} m/s
E) 1.83×10^{8} m/s

3. An electron gun inside a computer monitor sends an electron toward the screen at a speed of 1.20×10^{8} m/s. If the mass of the electron is 9.109×10^{-31} kg, what is the magnitude of its relativistic momentum?

A) 9.88×10^{-23} kg • m/s
B) 1.09×10^{-22} kg • m/s
C) 1.20×10^{-22} kg • m/s
D) 1.41×10^{-22} kg • m/s
E) 3.25×10^{-22} kg • m/s

4. At what speed is a particle traveling if its kinetic energy is three times its rest energy?

A) $0.879c$ B) $0.918c$ C) $0.943c$ D) $0.968c$ E) $0.989c$

Answer Key

1. **B** 1.3×10^{-18} kg • m/s
2. **D** 2.34×10^{8} m/s
3. **C** 1.20×10^{-22} kg • m/s
4. **D** $0.968c$

Name ______________________________ Per. ___ Date ____
DiBucci

Lab: Center of Mass

Objective: Apply the equation for the center of mass to a one dimensional system of masses located at different points along the meter stick.

Equation(s):

$$X_{cm} = \frac{x_1 m_1 + x_2 m_2 + x_3 m_3 + x_4 m_4 + x_5 m_5 \ldots}{m_1 + m_2 + m_3 + m_4 + m_5 \ldots}$$

Directions:

1. **Measure the mass of your meter stick and record it here : m5= _______kg**
2. **Assume all of the mass of the meter stick is located at the x5= 0.5m mark**
3. Place the four masses at the locations indicated in the data chart
4. Use the center of mass equation to calculate the theoretical center of mass (don't forget to take into account the mass of the meter stick)
5. Find the point on the stick where it is balanced and record it in the data table (this is the experimental value of the center of mass
6. Calculate the percent error

Note: all masses are in kg, and all distances are in meters

TRIAL	M1	X1	M2	X2	M3	X3	M4	X4	M5	X5	XCM
1	0.100	.1	0.050	.3	0.050	.25	0.020	.5			
2	0.100	.2	0.050	.25	0.050	.5	0.020	.3			
3	0.100	.9	0.050	.8	0.050	.15	0.020	.45			
4	0.100	.4	0.050	.1	0.050	.25	0.020	.4			
5	0.100	.2	0.050	.65	.0500	.8	0.020	.25			

trial	Experimental Xcm	Theoretical Xcm	% error
1			
2			
3			
4			
5			

Show calculations for trials one and two below

MOMENTUM DIBUCCI

Worksheet **AP Physics**

1. An 18.0 g rifle bullet traveling 230 m/s buries itself in a 3.6 kg pendulum hanging on a 2.8 m long string, which makes the pendulum swing upward in an arc. Determine the horizontal (x-direction) displacement of the pendulum. (Clue: the vertical (y-direction) displacement can be calculated using the methods described in class-then use a sketch to determine the final answer) (ANSWER: 0.61 m)

2. Derive a formula for the fraction of kinetic NRG lost ($\Delta K/K$) using a ballistic pendulum. Use only the follow symbols in the final answer: M_b= mass of bullet, M_p=mass of pendulum) (ANSWER: M_p/M_b+M_p)

3. An explosion breaks an object into two pieces one of which is 1.5 times the mass of the other. If 7500.0 J of NRG were released in the explosion, how much K did each piece acquire? (ANSWER: 3000 J for the less massive piece and 4500 J for the other piece)

4. A 1000 kg compact car collides with the back of a 2200 kg luxury car which was at rest. The bumpers and the brakes lock and the two cars slide forward 2.8 m before stopping. Using 0.40 as the coefficient of friction, determine the speed of the compact car prior to the collision. The speed limit on the road was 30 MPH. Was the compact car speeding? (ANSWER: 15 m/s, Yes)

5. A wooden block is cut into two pieces, one with three times the mass of the other. a depression is made in both faces of the cut so that a firecracker can be placed inside the reassembled block (with the wick sticking out). The entire system is set on a rough-surfaced table. When the firecracker explodes the pieces fly away from each other. What is the ratio of the distance that the lighter block travels when compared to the heavy block? (ANSWER: 9:1)

6. A 5.0 kg block moving in the +x direction at 5.5 m/s collides head-on with a 3.0 kg block moving in the -x direction at 4.0 m/s. Find the final velocity of each mass if:
a) The blocks stick together (ANSWER: both at 1.9 m/s)
b) The collision is perfectly elastic (ANSWER: -1.6 m/s and 7.9 m/s)

7. Determine the coefficient of restitution for a superball that rises to 90% of its original height after it hits the earth.
(ANSWER: e=0.95)

.W. PP. 204+205 IN the text
30, 31, 37, 38, 39, 42 TRY 36

UNIT 4 Review of Topics   AP Physics

1. Definitions of work and energy
2. Calculations of work......$W=Fs\cos\theta$
3. Graphical analysis of force and displacement
4. The work-energy theorem
5. The Grand-Master equation and problem solving
6. The concept of power...units and calculations
7. The concept of momentum
8. Impulse and change in momentum
9. Types of collisions and calculations with both (don't forget the momentum is a vector, therefore if the momentum is in 2 dimensions, you need a conservation of momentum equation in each direction)
    - Ballistic problems
    - Elastic and Inelastic cases

Unit 4 Practice Exam
AP Physics - B

Dibucci

UNTITLED

MULTIPLE CHOICE

1. A 40-N box is pulled 5.0 m up along a 37ø inclined plane. What is the work done by the weight (gravitational force) of the box?

a) -6.0 J
b) -12 J
c) -1.2X102 J
d) -2.0X102 J

2. Matthew pulls his little sister Sarah in a sled on an icy surface (assume no friction), with a force of 60.0 N at an angle of 37.0ø upward from the horizontal. If he pulls her a distance of 12.0 m, what is the work done by Matthew?

a) 185 J
b) 433 J
c) 575 J
d) 720 J

3.
A force moves an object in the direction of the

force. The graph shows the force versus the

object's position. Find the work done when the

object moves from 0 to 2.0 m.

a) 20 J
b) 40 J
c) 60 J
d) 80 J

4.
A force moves an object in the direction of the force. The graph shows the force versus the object's position. Find the work done when the object moves from 0 to 6.0 m.

a) 20 J
b) 40 J
c) 60 J
d) 80 J

5. Does the centripetal force acting on an object do work on the object?

a) Yes, since a force acts and the object moves, and work is force times distance.
b) Yes, since it takes energy to turn an object.
c) No, because the object has constant speed.
d) No, because the force and the displacement of the object are perpendicular.

6. You throw a ball straight up. Compare the sign of the work done by gravity while the ball goes up with the sign of the work done by gravity while it goes down.

a) Work is + on the way up and + on the way down.
b) Work is + on the way up and - on the way down.
c) Work is - on the way up and + on the way down.
d) Work is - on the way up and - on the way down.

7. A 10-kg mass, hung onto a spring, causes the spring to stretch 2.0 cm. What is the spring constant?

a) 4.9X103 N/m
b) 5.0X103 N/m
c) 20 N/m
d) 2.0 N/m

8. Calculate the work required to compress an initially uncompressed spring with a spring constant of 20 N/m by 15 cm.

a) 0.15 J
b) 0.30 J
c) 0.23 J
d) 0.45 J

9. What work is required to stretch a spring of spring constant 40 N/m from x = 0.20 m to 0.25 m? (Assume the unstretched position is at x = 0.)

a) 0.45 J
b) 0.80 J
c) 1.3 J
d) 0.050 J

10. A driver, traveling at 22 m/s, slows down her 2000 kg car to stop for a red light. What work is done by the friction force against the wheels?

a) -2.2X104 J
b) -4.4X104 J
c) -4.84X105 J
d) -9.68X105 J

11. A horizontal force of 200 N is applied to move a 55-kg cart (initially at rest) across a 10 m level surface. What is the final speed of the cart?

a) 73 m/s
b) 36 m/s
c) 8.5 m/s
d) 6.0 m/s

12. The kinetic friction force between a 60.0-kg object and a horizonatl surface is 50.0 N. If the initial speed of the object is 25.0 m/s, what distance will it slide before coming to a stop?

a) 15.0 m
b) 30.0 m
c) 375 m
d) 750 m

13. Is it possible for a system to have negative potential energy?

a) Yes, as long as the total energy is positive.
b) Yes, since the choice of the zero of potential energy is arbitrary.
c) No, because the kinetic energy of a system must equal its potential energy.
d) No, because this would have no physical meaning.

14. A 5.00-kg object is moved from a height of 3.00 m above a floor to a height of 7.00 m above the floor. What is the change in gravitational potential energy?

a) zero
b) 147 J
c) 196 J
d) 343 J

15. The total mechanical energy of a system

a) is equally divided between kinetic energy and potential energy.
b) is either all kinetic energy or all potential energy, at any one instant.
c) can never be negative.
d) is constant, only if conservative forces act.

16.
A roller coaster starts from rest at a point 45 m

above the bottom of a dip. Neglect friction,

what will be the speed of the roller coaster at

the top of the next slope, which is 30 m above

the bottom of the dip?

a) 14 m/s
b) 17 m/s
c) 24 m/s
d) 30 m/s

17.
A roller coaster starts at a point 30 m above the bottom of a dip with a speed of 25 m/s. Neglect friction, what will be the speed of the roller coaster at the top of the next slope, which is 45 m above the bottom of the dip?

a) 14 m/s
b) 16 m/s
c) 18 m/s
d) 20 m/s

18. A 60-kg skier starts from rest from the top of a 50-m high slope. What is the speed of the slier on reaching the bottom of the slope? (Neglect friction.)

a) 22 m/s
b) 31 m/s
c) 9.8 m/s
d) 41 m/s

19. A 1500-kg car moving at 25 m/s hits an initially uncompressed horizontal spring with spring constant of 2.0X106 N/m. What is the maximum compression of

the spring? (Neglect the mass of the spring.)

a) 0.17 m
b) 0.34 m
c) 0.51 m
d) 0.68 m

20. Consider two masses m1 and m2 at the top of two frictionless inclined planes. Both masses start from rest at the same height. However, the plane on which m1 sits is at an angle of 30ø with the horizontal, while the plane on which m2 sits is at 60ø. If the masses are released, which is going faster at the bottom of its plane?

a) m1
b) m2
c) They both are going the same speed.
d) Cannot be determined without knowing the masses.

21. A planet of constant mass orbits the sun in an elliptical orbit. Neglecting any friction effects, what happens to the planet's kinetic energy?

a) It remains constant.
b) It increases continually.
c) It decreases continually.
d) It increases when the planet approaches the sun, and decreases when it moves farther away.

22. A ball falls from the top of a building, through the air (air friction is present), to the ground below. How does the kinetic energy (K) just before striking the ground compare to the potential energy (U) at the top of the building?

a) K is equal to U.
b) K is greater than U.
c) K is less than U.
d) It is impossible to tell.

23. A 30.0-N stone is dropped from a height of 10.0 m, and strikes the ground with a velocity of 7.00 m/s. What average force of air friction acts on it as it falls?

a) 22.5 N
b) 75.0 N
c) 225 N
d) 293 N

24. A 2.0-kg mass is released from rest at the top of a plane inclined at 20ø above horizontal. The coefficient of kinetic friction between the mass and the plane is 0.20. What will be the speed of the mass after sliding 4.0 m along the plane?

a) 2.2 m/s
b) 3.0 m/s
c) 3.5 m/s
d) 5.2 m/s

25. A force of 10 N is applied horizontally to a 2.0-kg mass on a level

surface. The coefficient of kinetic friction between the mass and the surface is 0.20. If the mass is moved a distance of 10 m, what is the change in its kinetic energy?

a) 20 J
b) 39 J
c) 46 J
d) 61 J

26. How many joules of energy are used by a 1.0 hp motor that runs for 1.0 hr? (1 hp = 746 W)

a) 3.6X103 J
b) 2.7X106 J
c) 4.5X104 J
d) 4.8 J

27. A cyclist does work at the rate of 500 W while riding. How much force does her foot push with when she is traveling at 8.0 m/s?

a) 31 N
b) 63 N
c) 80 N
d) 4000 N

28. At what rate is a 60.0-kg boy using energy when he runs up a flight of stairs 10.0-m high, in 8.00 s?

a) 75.0 W
b) 735 W
c) 4.80 kW
d) 48 W

29. Compared to yesterday, you did 3 times the work in one-third the time. To do so, your power output must have been

a) the same as yesterday's power output.
b) one-third of yesterday's power output.
c) 3 times yesterday's power output.
d) 9 times yesterday's power output.

30. A ball, of mass 0.10 kg, is dropped from a height of 12 m. What is its momentum when it strikes the ground, in kgûm/s?

a) 1.5
b) 1.8
c) 2.4
d) 4.8

31. A 0.060-kg tennis ball, initially moving at a speed of 12 m/s, is struck by a racket causing it to rebound in the opposite direction at a speed of 18 m/s. What is the change in momentum of the ball?

a) 0.36 kgûm/s
b) 0.72 kgûm/s
c) 1.1 kgûm/s
d) 1.8 kgûm/s

32. A sailboat of mass m is moving with a momentum p. Which of the following represents its kinetic energy?

a) p2/(2m)
b) 1/2 mp2
c) mp
d) mp/2

33. A 50-kg pitching machine (excluding the baseball) is placed on a frozen pond. The machine fires a 0.40-kg baseball with a speed of 35 m/s in the horizontal friction. What is the recoil speed of the pitching machine? (Assume negligible friction.)

a) 0.14 m/s
b) 0.28 m/s
c) 0.70 m/s
d) 4.4X103 m/s

34. A 10.0-g bullet moving at 300 m/s is fired into a 1.00-kg block. The bullet emerges (the bullet does not embedded in the block) with half of its original speed. What is the velocity of the block right after the collision?

a) 1.50 m/s
b) 2.97 m/s
c) 3.00 m/s
d) 273 m/s

35. A 70-kg astronaut is space-walking outside the space capsule and is stationary when the tether line breaks. As a means of returning to the capsule he throws his 2.0-kg space hammer at a speed of 14 m/s away from the capsule. At what speed does the astronaut move toward the capsule?

a) 0.40 m/s
b) 1.5 m/s
c) 3.5 m/s
d) 5.0 m/s

36. A railroad freight car, mass 15,000 kg, is allowed to coast along a level track at a speed of 2.0 m/s. It collides and couples with a 50,000-kg second car, initially at rest and with brakes released. What is the speed of the two cars after coupling?

a) 0.46 m/s
b) 0.60 m/s
c) 1.2 m/s
d) 1.8 m/s

37. When a cannon fires a cannonball, the cannon will recoil backward because the

a) energy of the cannonball and cannon is conserved.
b) momentum of the cannonball and cannon is conserved.
c) energy of the cannon is greater than the energy of the cannonball.
d) momentum of the cannon is greater than the energy of the cannonball.

38. You (50-kg mass) skate on ice at 4.0 m/s to greet your friend (40-kg

mass), who is standing still, with open arms. As you collide, while holding each other, with what speed do you both move off together?

a) zero
b) 2.2 m/s
c) 5.0 m/s
d) 23 m/s

39. A constant 6.0-N net force acts for 4.0 s on a 12 kg object. What is the object's change of velocity?

a) 2.0 m/s
b) 12 m/s
c) 18 m/s
d) 288 m/s

40. A 0.10-kg ball is dropped onto a table top. The speeds of the ball right before and right after hitting the table top are 5.0 m/s and 4.0 m/s, respectively. If the collision between the ball and the table top lasts 0.15 s, what is the magnitude of the average force exerted on the ball by the table top?

a) 0.67 N
b) 1.3 N
c) 3.0 N
d) 6.0 N

41. A 2000-kg car, traveling to the right at 30 m/s, collides with a brick wall and comes to rest in 0.20 s. What is the average force the car exerts on the wall?

a) 12,000 N to the right.
b) 300,000 N to the right.
c) 60,000 N to the right.
d) none of the above.

42. The area under the curve on a Force versus time (F vs. t) graph represents

a) impulse.
b) momentum.
c) work.
d) kinetic energy.

43. In an elastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?

a) kinetic energy is also conserved.
b) kinetic energy is gained.
c) kinetic energy is lost.
d) none of the above.

44. In an inelastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?

a) Kinetic energy is also conserved.
b) Kinetic energy is gained.
c) Kinetic energy is lost.
d) None of the above.

45. When is kinetic energy conserved?

a) in elastic collisions
b) in inelastic collisions
c) in any collison in which the objects do not stick together
d) in all collisions

46. A rubber ball with a speed of 5.0 m/s collides head-on elastically with an identical ball at rest. What is the speed of the initially stopped ball after the collision?

a) zero
b) 1.0 m/s
c) 2.5 m/s
d) 5.0 m/s

47. A 50-gram ball moving +10 m/s collides head-on with a stationary ball of mass 100 g. The collision is elastic. What is the speed of each ball immediately after the collision?

a) -3.3 m/s and +6.7 m/s
b) +3.3 m/s and -6.7 m/s
c) -6.7 m/s and +3.3 m/s
d) +6.7 m/s and -3.3 m/s

48. Two objects move on a level frictionless surface. Object A moves east with a momentum of 24 kgûm/s. Object B moves north with momentum 10 kgûm/s. They make a perfectly inelastic collision. What is the magnitude of their combined momentum after the collision?

a) 14 kgûm/s
b) 26 kgûm/s
c) 34 kgûm/s
d) Cannot be determined without knowing masses and velocities.

49.
A 1500-kg car traveling at 90.0 km/h east collides with a 1000-kg car traveling at 60.0 km/h south. The two cars stick together after the collision. What is the speed of the cars after collision?

a) 8.33 m/s
b) 13.9 m/s
c) 17.4 m/s
d) 21.7 m/s

50. A small bomb, of mass 10 kg, is moving toward the North with a velocity of 4.0 m/s. It explodes into three fragments: a 5.0-kg fragment moving west with a speed of 8.0 m/s; a 4.0-kg fragment moving east with a speed of 10 m/s; and a third fragment with a mass of 1.0 kg. What is the velocity of the third fragment? (Neglect air friction.)

a) zero
b) 40 m/s north
c) 40 m/s south
d) None of the above

51. Two objects collide and stick together. Kinetic energy

a) is definitely conserved.
b) is definitely not conserved.
c) is conserved only if the collision is elastic.
d) is conserved only if the environment is frictionless.

52. A 2.0 kg mass moves with a speed of 5.0 m/s. It collides head-on with a 3.0 kg mass at rest. If the collision is perfectly inelastic, what is the speed of the masses after the collision?

a) 10 m/s
b) 2.5 m/s
c) 2.0 m/s
d) 0, since the collision is inelastic.

53. A 2.0-kg mass moving to the east at a speed of 4.0 m/s collides head-on in a perfectly inelastic collision with a stationary 2.0-kg mass. How much kinetic energy is lost during this collision?

a) 16 J
b) 4.0 J
c) 8.0 J
d) zero

ANSWER KEY FOR TEST UNTITLED

1. c

Chapter: 6 QUESTION: 1.

2. c

Chapter: 6 QUESTION: 2.

3. a

Chapter: 6 QUESTION: 3.

4. d

Chapter: 6 QUESTION: 4.

5. d

Chapter: 6 QUESTION: 5.

6. c

Chapter: 6 QUESTION: 6.

7. a

8. c

9. a

10. c

11. c

12. c

13. b

14. c

15. d

16. b

17. c

18. b

19. d

20. c

21. d

22. c

23. a

24. d

25. d

26. b

27. b

28. b

29. d

30. a

31. d

32. a

33. b

34. a

35. a

36. a

37. b

38. b

39. a

40. d

41. b

42. a

43. a

44. c

45. a

46. d

47. a

48. b

49. b

50. b

51. b

52. c

53. c

Chapter: 7 QU

Chapter: 7 QU

Chapter: 7 QU

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Chapter: 7 QU

Free response questions · Physics DiBucci

1) Reference: Fig. A – inelastic collision

In figure – A, there are two masses on a collision course, M1 and M2 as shown in the diagram. They hit and stick together. Calculate the final velocity (magnitude and direction) of the combined masses.

M1= 10.0 kg Vo1= 10.0 m/s at zero degrees

M2= 20.0 Kg Vo2= 5.0 m/s at 45 degrees North of east

2) Reference : Fig. B – elastic collision ?

In figure B, mass 1 is inbound on mass 2 that is intially at rest. After the collision the masses bounce off of one another at the angles indicated, mass 2 travels off at 10.0 m/s at an angle of 30 degrees south of east. Mass 1 travels off at an angle of 38.36 degrees north of east.

a) Calculate the final velocity of mass 1.
b) Calculate the difference between the initial and final kinetic energy. Is this a truly elastic collision?

3) Reference : Fig. C

A 1.0 kg box, initially at rest and a height of 30.0 m, begins sliding down a frictionless surface. When it recahes the bottom it starts sliding across the horizontal surface, then has a totally inelastic collision with a 2.0 kilogram box. Thy stick together and begin to slide off together. The combined system then encounters a 5.0 m of a surface with a coefficient of friction of 0.20. After leaving this surface the system is projected horizontally, from a vertical height of 5.0 m.

a) calculate the speed of the 1.0 kg block at the bottom of the hill
b) calculate the speed of the two block system after they collide.
c) Calculate the speed that the system has when it leaves the surface with friction and becomes a projectile.
d) Calculate the horizontal range of this projectile.

Fig. A - Inelastic

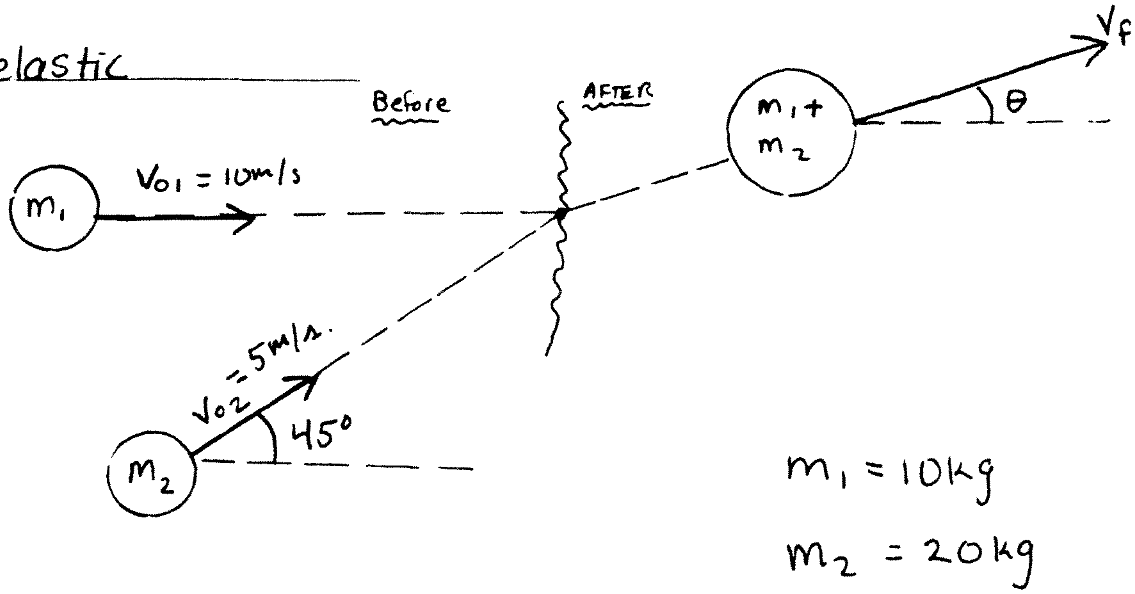


Fig. B - Elastic ?

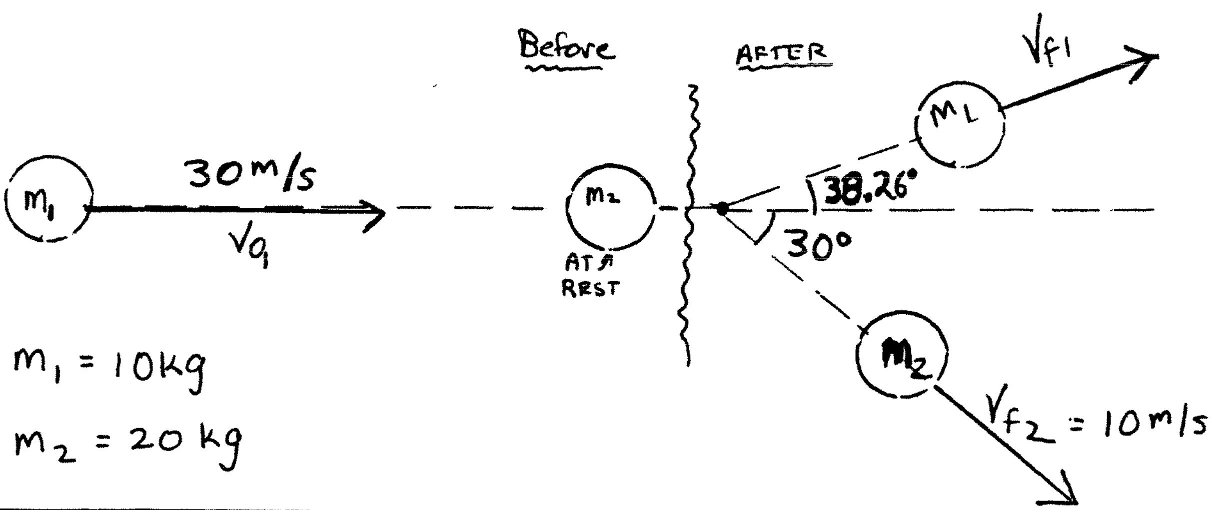
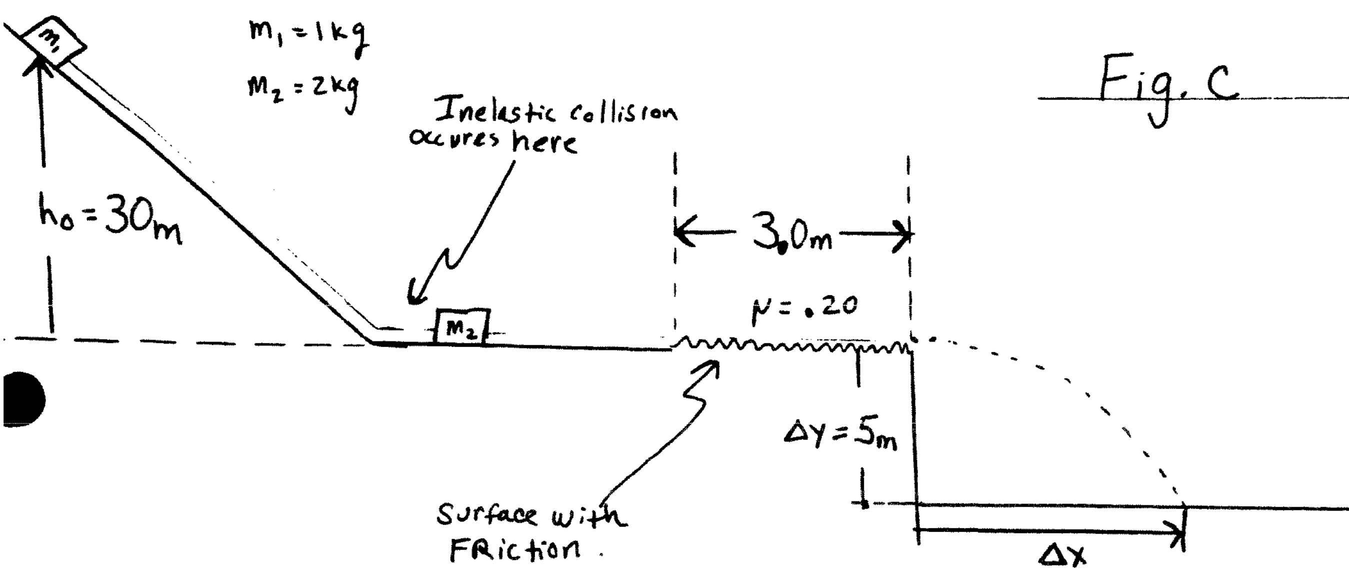


Fig. C



UNIT 4 REVIEW A.P. PHYSICS

4. A 10 Kg PACKAGE SLIDES DOWN AN 42° INCLINE. μ_K is .32 . THE PACKAGE TRAVELS 4.00 M.

FIND
a) THE WORK DONE BY FRICTION
b) THE WORK DONE BY GRAVITY
c) THE WORK DONE BY THE NORMAL FORCE.
D) THE TOTAL WORK
e) [redacted] CALCULATE THE TIME IT TAKES FOR THIS EXPERIMENT THEN DETERMINE THE POWER DEVELOPED.

5. A CART ON AN AIR TRACK CHANGES SPEED (UNDER THE INFLUENCE OF A FORCE) FROM 1.6 M/S TO .3 M/S. IF THE CART'S MASS IS .15 Kg, DETERMINE THE VALUE OF THE FORCE. [redacted] THE CART MOVED A DISTANCE OF .5 M DURING THE TIME THAT THE FORCE ACTED.

6. A 2.00 Kg BLOCK IS PUSHED UP AGAINST A SPRING WHOSE FORCE CONSTANT IS 400 $\frac{N}{M}$. THE BLOCK COMPRESSES THE SPRING .18 M. WHEN RELEASED, THE BLOCK SLIDES ACROSS A FRICTIONLESS PLANE AND THEN UP A 37° FRICTIONLESS INCLINE (SEE DRAWING)

a) AT WHAT SPEED DOES THE BLOCK SLIDE ON THE HORIZONTAL SURFACE AFTER IT LOSES CONTACT WITH THE SPRING?

b) HOW FAR WILL IT TRAVEL UP THE INCLINE?

Unit 4 Review sheet part 2 A. P. Physics

1. Answer the questions about a perfectly elastic collision between the two carts shown below:

a. Find the velocity v1 in terms of v2.

b. Describe the motion of the two carts after the collision (in words).

c. If the velocity of the big cart before the collision was 4m/s, determine the velocities v1 and v2.

d. What is the relative velocity of the carts prior to the collision?

e. What is the relative velocity of the carts after the collision?

Note: After the collision the velocity of the big cart is v1 and the velocity of the little cart is v2.

2. Repeat the problem in # 1 except have the little cart (mass = m) slam into the big cart whose mass is 10m. The initial velocity of the little cart is 6 m/s.

Solutions to FREE RESPONSE

1) $\underline{P_x}$ $\quad m_1V_1 + m_2V_2\cos 45° = (m_1 + m_2)V_x'$

$10(10) + (20)(5)\cos 45 = (30)V_x'$

$100 + 70.7 = 30V_x'$

$170.7 = 30V_x'$

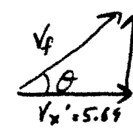
$\boxed{V_x' = 5.69\ m/s}$

$\underline{P_y}$: $m_1V_1\sin\theta + m_2V_2\sin 45° = (m_1+m_2)V_y'$

$0 + 20(5)(\sin 45°) = 30V_y'$

$70.7 = 30V_y'$

$\boxed{V_y' = 2.36}$



$\theta = \tan^{-1}\left(\frac{2.36}{5.69}\right) = \boxed{22.5°\ \text{above +x-axis}}$

$V_F = \sqrt{(5.69)^2 + (2.36)^2} = \boxed{6.16\ m/s}$

2) Conserve momentum in x

a) $(10)(30) = (10)V_1'\cos 38.26 + (20)(10)\cos 30°$

$300 = 7.85V_1' + 173.2$

$126.8 = 7.85V_1'$

$\boxed{V_1' = 16.15}$

Alternate momentum in y

$0 = (10)V_1'\sin 38.26° - (20)(10)\sin 30°$

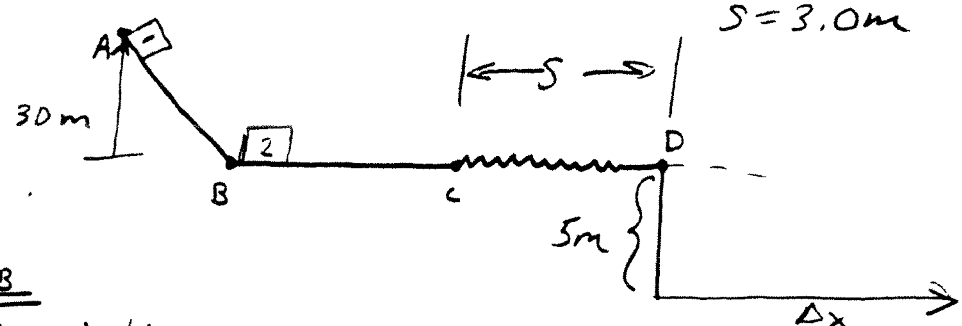
$V_1' = \frac{10}{\sin 38.26} = \boxed{16.14\ m/s}$

B) $\Sigma KE_0 = \frac{1}{2}(10)(30)^2 = 4516.1\ J$

$\Sigma KE_f = \frac{1}{2}(10)(16.14)^2 + \frac{1}{2}(20)(10)^2 = 2302.5\ J$

$\boxed{\Delta KE = -2213.6\ J,\ \text{NO}}$

3.



A) A→B

$m_1 g h_A = \frac{1}{2} m_1 V_B$

$V_B = \sqrt{2gh_A} = 24.2\,m/s$

B) B→C

$m_1 V_B + 0 = (m_1 + m_2) V_{system_c}$

$V_{system_c} = \frac{m_1 V_0}{(m_1 + m_2)} = \frac{1}{3}(24.2\,m/s) = 8.08\,m/s$

C) C→D

$\frac{1}{2} m_{system} V_{system_c}^2 + W_0 = \frac{1}{2} m_{system} V_D^2$

$\frac{1}{2} m_s V_{s,c}^2 - \mu m_s g s = \frac{1}{2} m_s V_D^2$

$\frac{1}{2} V_{s,c}^2 - \mu g s = \frac{1}{2} V_D^2$

$V_D = \sqrt{V_{s,c}^2 - 2\mu g s} = \sqrt{(8.08)^2 - 2(.2)(9.8)(3m)}$

$= 7.3\,m/s$

D) $\Delta y = \frac{1}{2}(-9.8)t^2$

$-5 = -4.9t^2$

$t = \sqrt{5/4.9} = 1.01\,s$

$\Delta x = V_D t$

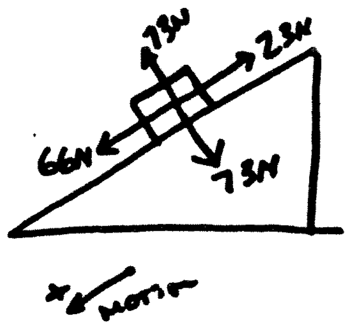
$= (7.3\,m/s)(1.01\,s)$

$= 7.4\,m$

ANSWERS

UNIT 4 REVIEW

4.



a) $W_{FRICTION} = 23N(\cos 180)\,4m = \underline{\underline{-92J}}$

b) $W_{gravity} = 66N(\cos 0)\,4m = \underline{\underline{264J}}$

c) $W_{F_N} = 73N(\cos 90)\,4m = \underline{\underline{0J}}$

d) $W_{TOTAL} =$ 172[redacted]J

e) $F_{NET} = ma$

$43N = 10kg\,(a)$

$4.3\frac{m}{s^2} = a$

$x = x_0 + v_0 \cdot t + \frac{1}{2}at^2$

$4.0 = 0 + 0 + \frac{1}{2}(4.3)\,t^2$

$1.4\,sec = t$

$P = \frac{W}{t} = \frac{172J}{1.4\,sec} = \underline{\underline{123\,WATTS}}$

5. $W = \Delta K$

$F \overset{\cos\theta}{\cdot} s = \frac{1}{2}Mv_2^2 - \frac{1}{2}Mv_1^2$

$F^{\cos 180}(.5m) = \frac{1}{2}(.15kg)(.3\frac{m}{s})^2 - \frac{1}{2}(.15kg)(1.6\frac{m}{s})^2$

$F = \underline{\underline{.37N}}$

6) 2 PARTS

A. ON HORIZONTAL

- ONLY FORCE ACTING IS SPRING FORCE

$\therefore \quad K_2 + U_{e_2} = K_1 + U_{e_1}$ BUT $U_{e_2} = 0$ (BLOCK NOT IN CONTACT)

AND $K_1 = 0$ (OBJECT AT REST)

$\therefore \quad K_2 = U_{e_1}$ IE.... TRANSFORMATION OF POTENTIAL TO KINETIC ENERGY.

$\frac{1}{2} M V_2^2 = \frac{1}{2} k x^2$

$\frac{1}{2}(2\ kg)(V_2)^2 = \frac{1}{2}(400\ \frac{N}{m})(.18\ M)^2$

$V_2 = \underline{\underline{2.55}}\ M/s$

B. ON INCLINE

- ONLY GRAVITATIONAL FORCE ACTING

$\therefore \quad K_2 + U_{g_2} = K_1 + U_{g_1}$ BUT $U_{g_1} = 0$ (NO HEIGHT)

AND $K_2 = 0$ (NO SPEED)

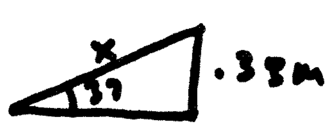
$U_{g_2} = K_1$ IE... TRANSFORMATION OF KINETIC TO POTENTIAL ENERGY

$M g Y_2 = \frac{1}{2} M V_1^2$

$9.8(Y_2) = \frac{1}{2}(2.55)^2$

$Y_2 = .33\ m$

$\therefore$



X = distance up ramp $= \frac{.33}{\sin 37} = \underline{\underline{.55\ M}}$

SOLUTIONS

1. 7 A

MOMENTUM

BEFORE = AFTER

$8mv + 0 = 8mv_1 + mv_2$

$8v = 8v_1 + v_2$

$v = v_1 + \frac{v_2}{8}$

$v^2 = \left(v_1 + \frac{v_2}{8}\right)^2$

$v^2 = v_1^2 + 2\left(\frac{v_1 v_2}{8}\right) + \left(\frac{v_2}{8}\right)^2$

ENERGY

BEFORE = AFTER

$\frac{1}{2}(8m)v^2 + 0 = \frac{1}{2}(8m)v_1^2 + \frac{1}{2}(m)v_2^2$

$8v^2 = 8v_1^2 + v_2^2$

$v^2 = v_1^2 + \frac{v_2^2}{8}$

SAME

BY SUBSTITUTION: $v_1^2 + \frac{v_1 v_2}{4} + \frac{v_2^2}{64} = v_1^2 + \frac{v_2^2}{8}$

$\frac{v_1 v_2}{4} + \frac{v_2^2}{64} = \frac{v_2^2}{8}$

$\frac{v_1 v_2}{4} = \frac{v_2^2}{8} - \frac{v_2^2}{64} = \frac{7}{64} v_2^2$

$\frac{v_1}{4} = \frac{7}{64} v_2$

$v_1 = \frac{28}{64} v_2 = .44 v_2$

1B: They both travel away from the collision in the same direction.... but the little one is moving faster.

1C: BY SUBSTITUTION $v = \frac{28}{64}v_2 + \frac{v_2}{8} = \frac{36}{64}v_2$ since $v = 4\,m/s = \frac{36}{64}v_2$ $\boxed{v_2 = 7.1\ m/s}$

and $v_1 = .44 v_2 = .44(7.1\ m/s) = \boxed{3.1\ m/s}$

1D. relative velocity prior to collision is 4 m/s ($v_{Big} = 4\,m/s$ $v_{Small} = 0$ — relative to earth — $\therefore v_{BS} = 4$ m/s)

$+x \rightarrow$

1E. relative ~~velocity~~ speed after collision 4 m/s too!

$v_{Big} = 3.1\ m/s \rightarrow$ $v_{Small} = 7.1\ m/s \rightarrow$ (relative to earth) $\therefore v_{BS} = 4\ m/s$

---

3. A **MOMENTUM**

BEFORE = AFTER

$mv + 0 = mv_2 + 10mv_1$

$v = v_2 + 10v_1$

$v^2 = v_2^2 + 20v_1v_2 + 100v_1^2$

ENERGY

Before = After

$\frac{1}{2}mv^2 + 0 = \frac{1}{2}mv_2^2 + \frac{1}{2}(10m)v_1^2$

$v^2 = v_2^2 + 10v_1^2$

BY SUBSTITUTION: $v_2^2 + 20v_1v_2 + 100v_1^2 = v_2^2 + 10v_1^2$

$20v_1v_2 = -90v_1^2$

$v_2 = \frac{-90}{20} v_1$

OR

$-\frac{20}{90} v_2 = v_1$

$-.22 v_2 = v_1$

3B: They travel away from the collision in opposite directions.... The little one is moving faster than the big one

3C BY SUBSTITUTION $v = v_2 + 10\left(-\frac{20}{90}\right)v_2$

since $v = 6\,m/s = \frac{-110}{90} v_2$ $\quad v_2 = -5\ m/s$

and $-.22 v_2 = v_1$

$-.22(-5\ m/s) = v_1$

$\boxed{1.1\ m/s = v_1}$

3D 6 m/s

3E −6 m/s

NOTE: RELATIVE SPEED DOESN'T CHANGE IN ELASTIC COLLISIONS

Chapter 6: Work and Energy

MULTIPLE CHOICE

1. Which of the following is the correct unit of work expressed in SI units?

   a) kg m/s^2
   b) kg m^2/s
   c) kg m^2/s^2
   d) kg^2 m/s^2

   Answer: c Difficulty: 1

2. A 40-N box is pulled 5.0 m up along a 37° inclined plane. What is the work done by the weight (gravitational force) of the box?

   a) -6.0 J
   b) -12 J
   c) $-1.2X10^2$ J
   d) $-2.0X10^2$ J

   Answer: c Difficulty: 2

3. You lift a 10 N physics book up in the air a distance of 1.0 m, at a constant velocity of 0.50 m/s. What is the work done by the weight of the book?

   a) +10 J
   b) -10 J
   c) +5.0 J
   d) -5.0 J

   Answer: b Difficulty: 1

4. The area under the curve, on a Force versus position (F vs. x) graph, represents

   a) work.
   b) kinetic energy.
   c) power.
   d) potential energy.

   Answer: a Difficulty: 1

5. A 500-kg elavator is pulled upward with a costant force of 5500 N for a distance of 50.0 m. What is the work done by the 5500 N force?

a) $2.75X10^5$ J
b) $-2.45X10^5$ J
c) $3.00X10^4$ J
d) $-5.20X10^5$ J

Answer: a Difficulty: 1

6. A 500-kg elavator is pulled upward with a costant force of 5500 N for a distance of 50.0 m. What is the work done by the weight of the elavator?

a) $2.75X10^5$ J
b) $-2.45X10^5$ J
c) $3.00X10^4$ J
d) $-5.20X10^5$ J

Answer: b Difficulty: 1

7. A 500-kg elavator is pulled upward with a costant force of 5500 N for a distance of 50.0 m. What is the net work done on the elavator?

a) $2.75X10^5$ J
b) $-2.45X10^5$ J
c) $3.00X10^4$ J
d) $-5.20X10^5$ J

Answer: c Difficulty: 1

8. Matthew pulls his little sister Sarah in a sled on an icy surface (assume no friction), with a force of 60.0 N at an angle of 37.0° upward from the horizontal. If he pulls her a distance of 12.0 m, what is the work done by Matthew?

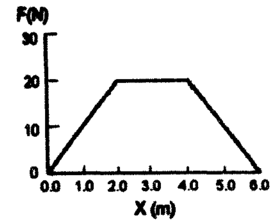
a) 185 J
b) 433 J
c) 575 J
d) 720 J

Answer: c Difficulty: 2

9. A 4.00-kg box of fruit slides 8.0 m down a ramp, inclined at 30.0° from the horizontal. If the box slides at a constant velocity of 5.00 m/s, what is the work done by the weight of the box?

a) 157 J
b) -157 J+78.4 J
c) 78.4 J
d) -78.4 J

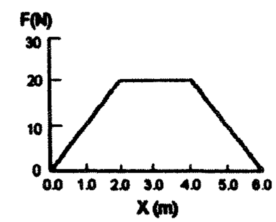
Answer: a Difficulty: 2



10. A force moves an object in the direction of the force. The graph shows the force versus the object's position. Find the work done when the object moves from 0 to 2.0 m.

a) 20 J
b) 40 J
c) 60 J
d) 80 J

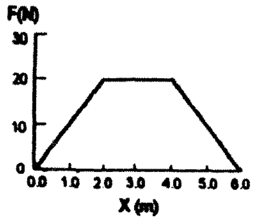
Answer: a Difficulty: 2



11. A force moves an object in the direction of the force. The graph shows the force versus the object's position. Find the work done when the object moves from 2.0 to 4.0 m.

a) 20 J
b) 40 J
c) 60 J
d) 80 J

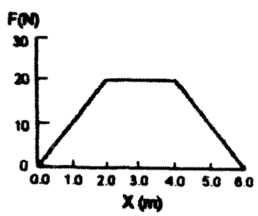
Answer: b Difficulty: 2



12. A force moves an object in the direction of the force. The graph shows the force versus the object's position. Find the work done when the object moves from 4.0 to 6.0 m.

a) 20 J
b) 40 J
c) 60 J
d) 80 J

Answer: c Difficulty: 2



13. A force moves an object in the direction of the force. The graph shows the force versus the object's position. Find the work done when the object moves from 0 to 6.0 m.

a) 20 J
b) 40 J
c) 60 J
d) 80 J

Answer: d Difficulty: 2

14. Can work be done on a system if there is no motion?

a) Yes, if an outside force is provided.
b) Yes, since motion is only relative.
c) No, since a system which is not moving has no energy.
d) No, because of the way work is defined.

Answer: d Difficulty: 1

15. If you push twice as hard against a stationary brick wall, the amount of work you do

a) doubles
b) is cut in half
c) remains constant but non-zero
d) remains constant at zero

Answer: d Difficulty: 1

16. A 50 N object was lifted 2.0 m vertically and is being held there. How much work is being done in holding the box in this position?

a) More than 100 J
b) 100 J
c) Less than 100 J, but more than 0 J
d) 0 J

Answer: d Difficulty: 2

17. An object is lifted vertically 2.0 m and held there. If the object weighs 120 N, how much work was done in lifting it?

a) 480 J
b) 240 J
c) 120 J
d) 0 J

Answer: b Difficulty: 1

18. Does the centripetal force acting on an object do work on the object?

a) Yes, since a force acts and the object moves, and work is force times distance.
b) Yes, since it takes energy to turn an object.
c) No, because the object has constant speed.
d) No, because the force and the displacement of the object are perpendicular.

Answer: d Difficulty: 2

19. You throw a ball straight up. Compare the sign of the work done by gravity while the ball goes up with the sign of the work done by gravity while it goes down.

a) Work is + on the way up and + on the way down.
b) Work is + on the way up and - on the way down.
c) Work is - on the way up and + on the way down.
d) Work is - on the way up and - on the way down.

Answer: c Difficulty: 1

20. A container of water is lifted vertically 3.0 m, then returned to its original position. If the total weight is 30 N, how much work was done?

a) 45 J
b) 90 J
c) 180 J
d) No work was done.

Answer: d Difficulty: 2

21. On a plot of Force versus position (F vs. x), what represents the work done by the force F?

a) The slope of the curve
b) The length of the curve
c) The area under the curve
d) The product of the maximum force times the maximum x

Answer: c Difficulty: 1

22. A 10-kg mass, hung onto a spring, causes the spring to stretch 2.0 cm. What is the spring constant?

a) $4.9X10^3$ N/m
b) $5.0X10^3$ N/m
c) 20 N/m
d) 2.0 N/m

Answer: a Difficulty: 1

23. Calculate the work required to compress an initially uncompressed spring with a spring constant of 20 N/m by 15 cm.

a) 0.15 J
b) 0.30 J
c) 0.23 J
d) 0.45 J

Answer: c Difficulty: 1

24. What work is required to stretch a spring of spring constant 40 N/m from x = 0.20 m to 0.25 m? (Assume the unstretched position is at x = 0.)

a) 0.45 J
b) 0.80 J
c) 1.3 J
d) 0.050 J

Answer: a Difficulty: 2

25. A spring is characterized by a spring constant of 60 N/m. How much potential energy does it store, when stretched by 1.0 cm?

a) $3.0X10^{-3}$ J
b) 0.30 J
c) 60 J
d) 600 J

Answer: a Difficulty: 1

26. A 0.200-kg mass attached to the end of a spring causes it to stretch 5.0 cm. If another 0.200-kg mass is added to the spring, the potential energy of the spring will be

a) the same.
b) twice as much.
c) 3 times as much.
d) 4 times as much.

Answer: d Difficulty: 2

27. A 4.0 kg mass is moving with speed 2.0 m/s. A 1.0 kg mass is moving with speed 4.0 m/s. Both objects encounter the same constant braking force, and are brought to rest. Which object travels the greater distance before stopping?

a) the 4.0 kg mass
b) the 1.0 kg mass
c) both travel the same distance
d) Cannot be determined from the information given.

Answer: c Difficulty: 2

28. A driver, traveling at 22 m/s, slows down her 2000 kg car to stop for a red light. What work is done by the friction force against the wheels?

a) $-2.2X10^4$ J
b) $-4.4X10^4$ J
c) $-4.84X10^5$ J
d) $-9.68X10^5$ J

Answer: c Difficulty: 1

29. A spring-driven dart gun propels a 10-g dart. It is cocked by exerting a force of 20 N over a distance of 5.0 cm. With what speed will the dart leave the gun, assuming the spring has negligible mass?

a) 10 m/s
b) 14 m/s
c) 17 m/s
d) 20 m/s

Answer: b Difficulty: 2

30. A horizontal force of 200 N is applied to move a 55-kg cart (initially at rest) across a 10 m level surface. What is the final kinetic energy of the cart?

a) $1.0X10^3$ J
b) $2.0X10^3$ J
c) $2.7X10^3$ J
d) $4.0X10^3$ J

Answer: b Difficulty: 1

31. A 100 N force has a horizontal component of 80 N and a vertical component of 60 N. The force is applied to a box which rests on a level frictionless floor. The cart starts from rest, and moves 2.0 m horizontally along the floor. What is the cart's final kinetic energy?

a) 200 J
b) 160 J
c) 120 J
d) zero

Answer: b Difficulty: 2

32. An arrow of mass 20 g, is shot horizontally into a bale of hay, striking the hay with a velocity of 60 m/s. It penetrates a depth of 20 cm before stopping. What is the average stopping force acting on the arrow?

a) 45 N
b) 90 N
c) 180 N
d) 360 N

Answer: c Difficulty: 2

33. A horizontal force of 200 N is applied to move a 55-kg cart (initially at rest) across a 10 m level surface. What is the final speed of the cart?

a) 73 m/s
b) 36 m/s
c) 8.5 m/s
d) 6.0 m/s

Answer: c Difficulty: 1

34. An object hits a wall and bounces back with half of its original speed. What is the ratio of the final kinetic energy to the initial kinetic energy?

a) 1/2
b) 1/4
c) 2
d) 4

Answer: b Difficulty: 2

35. If it takes 50 m to stop a car initially moving at 25 m/s, what distance is required to stop a car moving at 50 m/s under the same condition?

a) 50 m
b) 100 m
c) 200 m
d) 400 m

Answer: c Difficulty: 2

36. A 10-kg mass is moving with a speed of 4.0 m/s. How much work is required to stop the mass?

a) 20 J
b) 40 J
c) 60 J
d) 80 J

Answer: d Difficulty: 1

37. The kinetic friction force between a 60.0-kg object and a horizonatl surface is 50.0 N. If the initial speed of the object is 25.0 m/s, what distance will it slide before coming to a stop?

a) 15.0 m
b) 30.0 m
c) 375 m
d) 750 m

Answer: c Difficulty: 2

38. You slam on the brakes of your car in a panic, and skid a certain distance on a straight, level road. If you had been traveling twice as fast, what distance would the car have skidded, under the same conditions?

a) It would have skidded 4 times farther.
b) It would have skidded twice as far.
c) It would have skidded 1.4 times farther.
d) It is impossible to tell from the information given.

Answer: a Difficulty: 2

39. A truck weighs twice as much as a car, and is moving at twice the speed of the car. Which statement is true about the truck's kinetic energy (K) compared to that of the car?

a) All that can be said is that the truck has more K.
b) The truck has twice the K of the car.
c) The truck has 4 times the K of the car.
d) The truck has 8 times the K of the car.

Answer: d Difficulty: 1

40. Is it possible for a system to have negative potential energy?

a) Yes, as long as the total energy is positive.
b) Yes, since the choice of the zero of potential energy is arbitrary.
c) No, because the kinetic energy of a system must equal its potential energy.
d) No, because this would have no physical meaning.

Answer: b Difficulty: 1

41. A 5.00-kg object is moved from a height of 3.00 m above a floor to a height of 7.00 m above the floor. What is the change in gravitational potential energy?

a) zero
b) 147 J
c) 196 J
d) 343 J

Answer: c Difficulty: 2

42. A spring with a spring constant of 15 N/m is initially compressed by 3.0 cm. How much work is required to compress the spring an additional 4.0 cm?

a) 0.0068 J
b) 0.012 J
c) 0.024 J
d) 0.030 J

Answer: d Difficulty: 2

43. The total mechanical energy of a system

a) is equally divided between kinetic energy and potential energy.
b) is either all kinetic energy or all potential energy, at any one instant.
c) can never be negative.
d) is constant, only if conservative forces act.

Answer: d Difficulty: 1

44. An acorn falls from a tree. Compare its kinetic energy K, to its potential energy U.

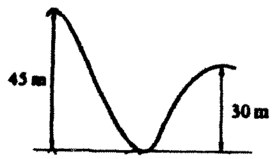
a) K increases and U decreases.
b) K decreases and U decreases.
c) K increases and U increases.
d) K decreases and U increases.

Answer: a Difficulty: 1

45. A roller coaster starts from rest at a point 45 m above the bottom of a dip. Neglect friction, what will be the speed of the roller coaster at the top of the next slope, which is 30 m above the bottom of the dip?

a) 14 m/s
b) 17 m/s
c) 24 m/s
d) 30 m/s

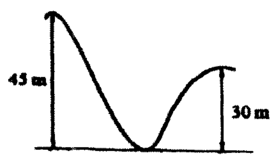
Answer: b Difficulty: 2



46. A roller coaster starts with a speed of 5.0 m/s at a point 45 m above the bottom of a dip. Neglect friction, what will be the speed of the roller coaster at the top of the next slope, which is 30 m above the bottom of the dip?

a) 12 m/s
b) 14 m/s
c) 16 m/s
d) 18 m/s

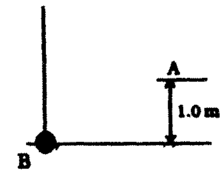
Answer: d Difficulty: 2



47. A roller coaster starts at a point 30 m above the bottom of a dip with a speed of 25 m/s. Neglect friction, what will be the speed of the roller coaster at the top of the next slope, which is 45 m above the bottom of the dip?

a) 14 m/s
b) 16 m/s
c) 18 m/s
d) 20 m/s

Answer: c Difficulty: 2



48. What is the minimum speed of the ball at the bottom of its swing (point B) in order for it to reach point A, which is 1.0-m above the bottom of the swing?

a) 2.2 m/s
b) 3.1 m/s
c) 4.4 m/s
d) 4.9 m/s

Answer: c Difficulty: 2

49. The quantity 1/2 mv^2 is

a) the kinetic energy of the object.
b) the potential energy of the object.
c) the work done on the object by the force.
d) the power supplied to the object by the force.

Answer: a Difficulty: 1

50. A toy rocket, weighing 10 N, blasts straight up from ground level with a kinetic energy of 40 J. At the exact top of its trajectory, its total mechanical energy is 140 J. To what vertical height does it rise?

a) 1.0 m
b) 10 m
c) 14 m
d) 24 m

Answer: b Difficulty: 2

51. Car J moves twice as fast as car K, and car J has half the mass of car K. The kinetic energy of car J, compared to car K is

a) the same.
b) 2 to 1.
c) 4 to 1.
d) 1 to 2.

Answer: b Difficulty: 2

52. A skier, of mass 40 kg, pushes off the top of a hill with an initial speed of 4.0 m/s. Neglecting friction, how fast will she be moving after dropping 10 m in elevation?

a) 7.3 m/s
b) 15 m/s
c) 49 m/s
d) 196 m/s

Answer: b Difficulty: 2

53. An object slides down a frictionless inclined plane. At the bottom, it has a speed of 9.80 m/s. What is the vertical height of the plane?

a) 19.6 m
b) 9.80 m
c) 4.90 m
d) 2.45 m

Answer: c Difficulty: 2

54. A 60-kg skier starts from rest from the top of a 50-m high slope. What is the speed of the slier on reaching the bottom of the slope? (Neglect friction.)

a) 22 m/s
b) 31 m/s
c) 9.8 m/s
d) 41 m/s

Answer: b Difficulty: 1

55. A lightweight object and a very heavy object are sliding with equal speeds along a level frictionless surface. They both slide up the same frictionless hill. Which rises to a greater height?

a) The heavy object, because it has greater kinetic energy.
b) The lightweight object, because it weighs less.
c) They both slide to the same height.
d) Cannot be determined from the information given.

Answer: c Difficulty: 2

56. A 12 kg object is moving on a rough, level surface. It has 24 J of kinetic energy. The friction force on it is a constant 0.50 N. How far will it slide?

a) 2.0 m
b) 12 m
c) 24 m
d) 48 m

Answer: d Difficulty: 2

57. A 1500-kg car moving at 25 m/s hits an initially uncompressed horizontal spring with spring constant of $2.0 X 10^6$ N/m. What is the maximum compression of the spring? (Neglect the mass of the spring.)

a) 0.17 m
b) 0.34 m
c) 0.51 m
d) 0.68 m

Answer: d Difficulty: 2

58. A brick is moving at a speed of 3 m/s and a pebble is moving at a speed of 5 m/s. If both objects have the same kinetic energy, what is the ratio of the brick's mass to the rock's mass?

a) 25 to 9
b) 5 to 3
c) 12.5 to 4.5
d) 3 to 5

Answer: a Difficulty: 2

59. Consider two masses m_1 and m_2 at the top of two frictionless inclined planes. Both masses start from rest at the same height. However, the plane on which m_1 sits is at an angle of 30° with the horizontal, while the plane on which m_2 sits is at 60°. If the masses are released, which is going faster at the bottom of its plane?

a) m_1
b) m_2
c) They both are going the same speed.
d) Cannot be determined without knowing the masses.

Answer: c Difficulty: 2

60. Describe the energy of a car driving up a hill.

a) entirely kinetic
b) entirely potential
c) both kinetic and potential
d) gravitational

Answer: c Difficulty: 2

61. A 1.0-kg ball falls to the floor. When it is 0.70 m above the floor, its potential energy exactly equals its kinetic energy. How fast is it moving?

a) 3.7 m/s
b) 6.9 m/s
c) 14 m/s
d) 45 m/s

Answer: a Difficulty: 2

62. A 400-N box is pushed up an inclined plane. The plane is 4.0 m long and rises 2.0 m. If the plane is frictionless, how much work was done by the push?

a) 1600 J
b) 800 J
c) 400 J
d) 100 J

Answer: b Difficulty: 2

63. A projectile of mass m leaves the ground with a kinetic energy of 220 J. At the highest point in its trajectory, its kinetic energy is 120 J. To what vertical height, relative to its launch point, did it rise?

a) 220/(mg) meters
b) 120/(mg) meters
c) 100/(mg) meters
d) Impossible to determine without knowing the angle of launch.

Answer: c Difficulty: 2

64. A pendulum of length 50 cm is pulled 30 cm away from the vertical axis and released from rest. What will be its speed at the bottom of its swing?

a) 0.50 m/s
b) 0.79 m/s
c) 1.2 m/s
d) 1.4 m/s

Answer: d Difficulty: 2

65. A planet of constant mass orbits the sun in an elliptical orbit. Neglecting any friction effects, what happens to the planet's kinetic energy?

a) It remains constant.
b) It increases continually.
c) It decreases continually.
d) It increases when the planet approaches the sun, and decreases when it moves farther away.

Answer: d Difficulty: 2

66. A ball falls from the top of a building, through the air (air friction is present), to the ground below. How does the kinetic energy (K) just before striking the ground compare to the potential energy (U) at the top of the building?

a) K is equal to U.
b) K is greater than U.
c) K is less than U.
d) It is impossible to tell.

Answer: c Difficulty: 2

67. A ball drops some distance and gains 30 J of kinetic energy. Do not ignore air resistance. How much gravitational potential energy did the ball lose?

a) More than 30 J
b) Exactly 30 J
c) Less than 30 J
d) Cannot be determined from the information given.

Answer: a Difficulty: 2

68. A ball drops some distance and loses 30 J of gravitational potential energy. Do not ignore air resistance. How much kinetic energy did the ball gain?

a) More than 30 J
b) Exactly 30 J
c) Less than 30 J
d) Cannot be determined from the information given.

Answer: c Difficulty: 2

69. A 30.0-N stone is dropped from a height of 10.0 m, and strikes the ground with a velocity of 7.00 m/s. What average force of air friction acts on it as it falls?

a) 22.5 N
b) 75.0 N
c) 225 N
d) 293 N

Answer: a Difficulty: 3

70. A 60-kg skier starts from rest from the top of a 50-m high slope. If the work done by friction is $-6.0X10^3$ J, what is the speed of the skier on reaching the bottom of the slope?

a) 17 m/s
b) 24 m/s
c) 28 m/s
d) 31 m/s

Answer: c Difficulty: 2

71. A 2.0-kg mass is released from rest at the top of a plane inclined at 20° above horizontal. The coefficient of kinetic friction between the mass and the plane is 0.20. What will be the speed of the mass after sliding 4.0 m along the plane?

a) 2.2 m/s
b) 3.0 m/s
c) 3.5 m/s
d) 5.2 m/s

Answer: d Difficulty: 3

72. An 800-N box is pushed up an inclined plane. The plane is 4.0 m long and rises 2.0 m. It requires 3200 J of work to get the box to the top of the plane. What was the magnitude of the average friction force on the box?

a) 0 N
b) Non-zero, but less than 400 N
c) 400 N
d) Greater than 400 N

Answer: c Difficulty: 2

73. A force of 10 N is applied horizontally to a 2.0-kg mass on a level surface. The coefficient of kinetic friction between the mass and the surface is 0.20. If the mass is moved a distance of 10 m, what is the change in its kinetic energy?

a) 20 J
b) 39 J
c) 46 J
d) 61 J

Answer: d Difficulty: 2

74. How many joules of energy are used by a 1.0 hp motor that runs for 1.0 hr? (1 hp = 746 W)

a) $3.6X10^3$ J
b) $2.7X10^6$ J
c) $4.5X10^4$ J
d) 4.8 J

Answer: b Difficulty: 1

75. A cyclist does work at the rate of 500 W while riding. How much force does her foot push with when she is traveling at 8.0 m/s?

a) 31 N
b) 63 N
c) 80 N
d) 4000 N

Answer: b Difficulty: 1

76. At what rate is a 60.0-kg boy using energy when he runs up a flight of stairs 10.0-m high, in 8.00 s?

a) 75.0 W
b) 735 W
c) 4.80 kW
d) 48 W

Answer: b Difficulty: 1

77. A 1500-kg car accelerates from 0 to 25 m/s in 7.0 s. What is the average power delivered by the engine? (1 hp = 746 W)

a) 60 hp
b) 70 hp
c) 80 hp
d) 90 hp

Answer: d Difficulty: 2

78. To accelerate your car at a constant acceleration, the car's engine must

a) maintain a constant power output.
b) develop ever-decreasing power.
c) develop ever-increasing power.
d) maintain a constant turning speed.

Answer: c Difficulty: 2

79. Compared to yesterday, you did 3 times the work in one-third the time. To do so, your power output must have been

a) the same as yesterday's power output.
b) one-third of yesterday's power output.
c) 3 times yesterday's power output.
d) 9 times yesterday's power output.

Answer: d Difficulty: 1

80. A 10-N force is needed to move an object with a constant velocity of 5.0 m/s. What power must be delivered to the object by the force?

a) 0.50 W
b) 1.0 W
c) 50 W
d) 100 W

Answer: c Difficulty: 1

81. The quantity Fd/t is

a) the kinetic energy of the object.
b) the potential energy of the object.
c) the work done on the object by the force.
d) the power supplied to the object by the force.

Answer: d Difficulty: 1

82. A person goes up a flight of stairs in 20 s. If the person weighs 600 N, and the vertical height of the stairs is 10 m, what is the person's power output?

a) 2.0 W
b) 300 W
c) 1.2 kW
d) 120 kW

Answer: b Difficulty: 2

83. Of the following, which is not a unit of power?

a) watt/second
b) newton-meter/second
c) joule/second
d) watt

Answer: a Difficulty: 2

MULTIPLE CHOICE

1. The SI unit of momentum is which of the following?

a) N·m
b) N/s
c) N·s
d) N/m

Answer: c Difficulty: 1

2. What is the momentum of a 2000 kg truck traveling at 20 m/s?

a) 1.0×10^{2} kg·m/s
b) 2.0×10^{4} kg·m/s
c) 4.0×10^{4} kg·m/s
d) 4.0×10^{5} kg·m/s

Answer: c Difficulty: 1

3. A 1200-kg ferryboat is moving south at 20 m/s. What is the magnitude of its momentum?

a) 1.7×10^{-3} kg·m/s
b) 6.0×10^{2} kg·m/s
c) 2.4×10^{3} kg·m/s
d) 2.4×10^{4} kg·m/s

Answer: d Difficulty: 1

4. A ball of mass 0.10 kg is dropped from a height of 12 m. Its momentum when it strikes the ground is

a) 1.5 kg·m/s
b) 1.8 kg·m/s
c) 2.4 kg·m/s
d) 4.8 kg·m/s

Answer: a Difficulty: 2

5. If you pitch a baseball with twice the kinetic energy you gave it in the previous pitch, the magnitude of its momentum is

a) the same.
b) 1.41 times as much.
c) doubled.
d) 4 times as much.

Answer: b Difficulty: 1

6. A ball, of mass 0.10 kg, is dropped from a height of 12 m. What is its momentum when it strikes the ground, in kg·m/s?

a) 1.5
b) 1.8
c) 2.4
d) 4.8

Answer: a Difficulty: 2

7. If the momentum of an object is doubled, by what factor will its kinetic energy change?

a) 2
b) 4
c) 1/2
d) 1/4

Answer: b Difficulty: 2

8. Two identical 1500-kg cars are moving perpendicular to each other. One moves with a speed of 25 m/s due north and the other moves at 15 m/s due east. What is the total momentum of the system?

a) 4.4×10^{4} kg·m/s at 31° N of E
b) 4.4×10^{4} kg·m/s at 59° N of E
c) 6.0×10^{4} kg·m/s at 31° N of E
d) 6.0×10^{4} kg·m/s at 59° N of E

Answer: b Difficulty: 2

9. A small object with a momentum of magnitude 5.0 kg·m/s approaches head-on a large object at rest. The small object bounces straight back with a momentum of magnitude 4.0 kg·m/s. What is the magnitude of the small object's momentum change?

a) 9.0 kg·m/s
b) 5.0 kg·m/s
c) 4.0 kg·m/s
d) 1.0 kg·m/s

Answer: a Difficulty: 2

10. A 0.060-kg tennis ball, initially moving at a speed of 12 m/s, is struck by a racket causing it to rebound in the opposite direction at a speed of 18 m/s. What is the change in momentum of the ball?

a) 0.36 kg·m/s
b) 0.72 kg·m/s
c) 1.1 kg·m/s
d) 1.8 kg·m/s

Answer: d Difficulty: 2

11. A 100-kg football linebacker moving at 2.0 m/s tackles head-on an 80-kg halfback running 3.0 m/s. Neglecting the effects due to digging in of cleats,

a) the linebacker will drive the halfback backward.
b) the halfback will drive the linebacker backward.
c) neither player will drive the other backward.
d) this is a simple example of an elastic collision.

Answer: b Difficulty: 2

12. A sailboat of mass m is moving with a momentum p. Which of the following represents its kinetic energy?

a) $p^2/(2m)$
b) $1/2\ mp^2$
c) mp
d) mp/2

Answer: a Difficulty: 1

13. A small car meshes with a large truck in a head-on collision. Which of the following statements concerning the magnitude of the average collision force is correct?

a) The truck experiences the greater average force.
b) The small car experiences the greater average force.
c) The small car and the truck experience the same average force.
d) It is impossible to tell since the masses and velocities are not given.

Answer: c Difficulty: 1

14. A 50-kg pitching machine (excluding the baseball) is placed on a frozen pond. The machine fires a 0.40-kg baseball with a speed of 35 m/s in the horizontal friction. What is the recoil speed of the pitching machine? (Assume negligible friction.)

a) 0.14 m/s
b) 0.28 m/s
c) 0.70 m/s
d) $4.4X10^3$ m/s

Answer: b Difficulty: 1

15. Two objects collide and stick together. Linear momentum

a) is definitely conserved.
b) is definitely not conserved.
c) is conserved only if the collision is elastic.
d) is conserved only if the environment is frictionless.

Answer: a Difficulty: 1

16. Two objects collide and bounce off each other. Linear momentum

a) is definitely conserved.
b) is definitely not conserved.
c) is conserved only if the collision is elastic.
d) is conserved only if the environment is frictionless.

Answer: a Difficulty: 2

17. A 3.0-kg object moves to the right at 4.0 m/s. It collides head-on with a 6.0-kg object moving to the left at 2.0 m/s. Which statement is correct?

a) The total momentum both before and after the collision is 24 kg·m/s.
b) The total momentum before the collison is 24 kg·m/s, and after the collision is 0 kg·m/s.
c) The total momentum both before and after the collision is zero.
d) None of the above is true.

Answer: c Difficulty: 2

18. When a light beach ball rolling with a speed of 6.0 m/s collides with a heavy exercise ball at rest, the beach ball's speed after the collision will be, approximately,

a) 0
b) 3.0 m/s
c) 6.0 m/s
d) 12 m/s

Answer: c Difficulty: 2

19. A 10.0-g bullet moving at 300 m/s is fired into a 1.00-kg block. The bullet emerges (the bullet does not embedded in the block) with half of its original speed. What is the velocity of the block right after the collision?

a) 1.50 m/s
b) 2.97 m/s
c) 3.00 m/s
d) 273 m/s

Answer: a Difficulty: 2

20. A small object with momentum 5.0 kg·m/s approaches head-on a large object at rest. The small object bounces straight back with a momentum of magnitude 4.0 kg·m/s. What is the magnitude of the large object's momentum change?

a) 9.0 kg·m/s
b) 5.0 kg·m/s
c) 4.0 kg·m/s
d) 1.0 kg·m/s

Answer: a Difficulty: 2

21. A small object collides with a large object and sticks. Which object experiences the larger magnitude of momentum change?

a) the large object
b) the small object
c) Both objects experienece the same magnitude of momentum change.
d) Cannot be determined from the information given.

Answer: c Difficulty: 2

22. Which of the following is an accurate statement?

a) The momentum of a projectile is constant.
b) The momentum of a moving object is constant.
c) If an object is acted on by a non-zero net external force, its momentum will not remain constant.
d) If the kinetic energy of an object is doubled, its momentum will also double.

Answer: c Difficulty: 1

23. Two astronauts, of masses 60 kg and 80 kg, are initially at rest in outer space. They push each other apart. What is their separation after the lighter astronaut has moved 12 m?

a) 15 m
b) 18 m
c) 21 m
d) 24 m

Answer: c Difficulty: 2

24. A 70-kg astronaut is space-walking outside the space capsule and is stationary when the tether line breaks. As a means of returning to the capsule he throws his 2.0-kg space hammer at a speed of 14 m/s away from the capsule. At what speed does the astronaut move toward the capsule?

a) 0.40 m/s
b) 1.5 m/s
c) 3.5 m/s
d) 5.0 m/s

Answer: a Difficulty: 1

25. A car of mass 1000 kg moves to the right along a level, straight road at a speed of 6.0 m/s. It collides directly with a stopped motorcycle of mass 200 kg. What is the total momentum after the collision?

a) zero
b) 6000 kg·m/s to the right
c) 2000 kg·m/s to the right
d) 10,000 kg·m/s to the right

Answer: b Difficulty: 2

26. A railroad freight car, mass 15,000 kg, is allowed to coast along a level track at a speed of 2.0 m/s. It collides and couples with a 50,000-kg second car, initially at rest and with brakes released. What is the speed of the two cars after coupling?

a) 0.46 m/s
b) 0.60 m/s
c) 1.2 m/s
d) 1.8 m/s

Answer: a Difficulty: 2

27. When a cannon fires a cannonball, the cannon will recoil backward because the

a) energy of the cannonball and cannon is conserved.
b) momentum of the cannonball and cannon is conserved.
c) energy of the cannon is greater than the energy of the cannonball.
d) momentum of the cannon is greater than the energy of the cannonball.

Answer: b Difficulty: 1

28. You (50-kg mass) skate on ice at 4.0 m/s to greet your friend (40-kg mass), who is standing still, with open arms. As you collide, while holding each other, with what speed do you both move off together?

a) zero
b) 2.2 m/s
c) 5.0 m/s
d) 23 m/s

Answer: b Difficulty: 2

29. A 1000-kg car traveling at 25 m/s runs into the rear of a stopped car that has a mass of 1500 kg and they stick together. What is the speed of the cars after the collision?

a) 5.0 m/s
b) 10 m/s
c) 15 m/s
d) 20 m/s

Answer: b Difficulty: 2

30. A 60-kg person walks on a 100-kg log at the rate of 0.80 m/s (with respect to the log). With what speed does the log move, with respect to the shore?

a) 0.24 m/s
b) 0.30 m/s
c) 0.48 m/s
d) 0.60 m/s

Answer: b Difficulty: 3

31. A toy rocket, of mass 0.12 kg, achieves a velocity of 40 m/s after 3.0 s, when fired straight up. What average thrust force does the rocket engine exert?

a) 1.2 N
b) 1.6 N
c) 2.8 N
d) 4.4 N

Answer: c Difficulty: 3

32. A rubber ball and a lump of putty have equal mass. They are thrown with equal speed against a wall. The ball bounces back with nearly the same speed with which it hit. The putty sticks to the wall. Which objects experiences the greater momentum change?

a) the ball
b) the putty
c) Both experience the same momentum change.
d) Cannot be determined from the information given.

Answer: a Difficulty: 2

33. A constant 6.0-N net force acts for 4.0 s on a 12 kg object. What is the object's change of velocity?

a) 2.0 m/s
b) 12 m/s
c) 18 m/s
d) 288 m/s

Answer: a Difficulty: 1

34. A 4.0-N force acts for 3.0 s on an object. The force suddenly increases to 15 N and acts for one more second. What impulse was imparted by these forces to the object?

a) 12 N·s
b) 15 N·s
c) 16 N·s
d) 27 N·s

Answer: d Difficulty: 2

35. A 0.10-kg ball is dropped onto a table top. The speeds of the ball right before and right after hitting the table top are 5.0 m/s and 4.0 m/s, respectively. If the collision between the ball and the table top lasts 0.15 s, what is the magnitude of the average force exerted on the ball by the table top?

a) 0.67 N
b) 1.3 N
c) 3.0 N
d) 6.0 N

Answer: d Difficulty: 2

36. A 2.0-kg softball is pitched to you at 20 m/s. You hit the ball back along the same path, and at the same speed. If the bat was in contact with the ball for 0.10 s, what is the magnitude of the average force the bat exerted?

a) zero
b) 40 N
c) 400 N
d) 800 N

Answer: d Difficulty: 2

37. A 2000-kg car, traveling to the right at 30 m/s, collides with a brick wall and comes to rest in 0.20 s. What is the average force the car exerts on the wall?

a) 12,000 N to the right.
b) 300,000 N to the right.
c) 60,000 N to the right.
d) none of the above.

Answer: b Difficulty: 1

38. The area under the curve on a Force versus time (F vs. t) graph represents

a) impulse.
b) momentum.
c) work.
d) kinetic energy.

Answer: a Difficulty: 1

39. A handball of mass 0.10 kg, traveling horizontally at 30 m/s, strikes a wall and rebounds at 24 m/s. What is the change in the momentum of the ball?

a) 0.60 kg·m/s
b) 1.2 kg·m/s
c) 5.4 kg·m/s
d) 72 kg·m/s

Answer: c Difficulty: 2

40. A machine gun, of mass 35.0 kg, fires 50.0-gram bullets, with a muzzle velocity of 750 m/s, at the rate of 300 rounds per minute. What is the average force exerted on the machine gun mount?

a) 94.0 N
b) 188 N
c) 219 N
d) 438 N

Answer: b Difficulty: 2

41. A fire hose is turned on the door of a burning building in order to knock the door down. This requires a force of 1000 N. If the hose delivers 40 kg per second, what is the minimum velocity of the stream needed, assuming the water doesn't bounce back?

a) 15 m/s
b) 20 m/s
c) 25 m/s
d) 30 m/s

Answer: c Difficulty: 2

42. Water runs out of a horizontal drainpipe at the rate of 120 kg per minute. It falls 3.20 m to the ground. Assuming the water doesn't splash up, what average force does it exert on the ground?

a) 6.20 N
b) 12.0 N
c) 15.8 N
d) 19.6 N

Answer: c Difficulty: 3

43. Two equal mass balls (one red and the other blue) are dropped from the same height, and rebound off the floor. The red ball rebounds to a higher position. Which ball is subjected to the greater magnitude of impulse during its collision with the floor?

a) It's impossible to tell since the time intervals and forces are unknown.
b) Both balls were subjected to the same magnitude impulse.
c) the blue ball
d) the red ball

Answer: d Difficulty: 2

44. A Ping-Pong ball moving east at a speed of 4 m/s, collides with a stationary bowling ball. The Ping-Pong ball bounces back to the west, and the bowling ball moves very slowly to the east. Which object experiences the greater magnitude impulse during the collision?

a) Neither; both experienced the same magnitude impulse.
b) the Ping-Pong ball
c) the bowling ball
d) It's impossible to tell since the velocities after the collision are unknown.

Answer: a Difficulty: 2

45. In an elastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?

a) kinetic energy is also conserved.
b) kinetic energy is gained.
c) kinetic energy is lost.
d) none of the above.

Answer: a Difficulty: 1

46. In an inelastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?

a) Kinetic energy is also conserved.
b) Kinetic energy is gained.
c) Kinetic energy is lost.
d) None of the above.

Answer: c Difficulty: 1

47. When is kinetic energy conserved?

a) in elastic collisions
b) in inelastic collisions
c) in any collison in which the objects do not stick together
d) in all collisions

Answer: a Difficulty: 1

48. A very large object moving with velocity v collides head-on with a very small object moving with velocity -v. The collision is elastic, and there is no friction. The large object barely slows down. What is the speed of the small object after the collision?

a) nearly v
b) nearly 2v
c) nearly 3v
d) nearly infinite

Answer: c Difficulty: 3

49. A very large object moving with speed v collides head-on with a very small object at rest. The collision is elastic, and there is no friction. The large object barely slows down. What is the speed of the small object after the collision?

a) nearly v
b) nearly 2v
c) nearly 3v
d) nearly infinite

Answer: b Difficulty: 2

50. A rubber ball with a speed of 5.0 m/s collides head-on elastically with an identical ball at rest. What is the speed of the initially stopped ball after the collision?

a) zero
b) 1.0 m/s
c) 2.5 m/s
d) 5.0 m/s

Answer: d Difficulty: 2

51. A very small object moving with speed v collides head-on with a very large object at rest, in a frictionless environment. The collision is almost perfectly elastic. The speed of the large object after the collison is

a) slightly greater than v.
b) equal to v.
c) slightly less than v.
d) much less than v.

Answer: d Difficulty: 2

52. A proton, of mass m, at rest, is struck head-on by an alpha-particle (which consists of 2 protons and 2 neutrons) moving at speed v. If the collision is completely elastic, what speed will the alpha-particle have after the collision? (Assume the neutron's mass equals the proton's mass.)

a) zero
b) 2v/3
c) 3v/5
d) 5v/3

Answer: c Difficulty: 3

53. A 50-gram ball moving +10 m/s collides head-on with a stationary ball of mass 100 g. The collision is elastic. What is the speed of each ball immediately after the collision?

a) -3.3 m/s and +6.7 m/s
b) +3.3 m/s and -6.7 m/s
c) -6.7 m/s and +3.3 m/s
d) +6.7 m/s and -3.3 m/s

Answer: a Difficulty: 3

54. A 0.10-kg object with a velocity of 0.20 m/s in the +x direction makes a head-on elastic collision with a 0.15 kg object initially at rest. What is the final velocity of the 0.10-kg object after collision?

a) -0.16 m/s
b) +0.16 m/s
c) -0.040 m/s
d) +0.040 m/s

Answer: c Difficulty: 2

55. In a game of pool, the white cue ball hits the #5 ball and stops, while the #5 ball moves away with the same velocity as the cue ball had originally. The type of collision is

a) elastic.
b) inelastic.
c) completely inelastic.
d) any of the above, depending on the mass of the balls.

Answer: a Difficulty: 2

56. A 3.0-kg object moves to the right with a speed of 4.0 m/s. It collides in a perfectly elastic collision with a 6.0-kg object moving to the left at 2.0 m/s. What is the total kinetic energy after the collision?

a) 72 J
b) 36 J
c) 24 J
d) 0 J

Answer: b Difficulty: 2

57. A golf ball traveling 3.0 m/s to the right collides in a head-on collision with a stationary bowling ball in a friction-free environment. If the collision is almost perfectly elastic, the speed of the golf ball immediately after the collision is

a) slightly less than 3.0 m/s.
b) slightly greater than 3.0 m/s.
c) equal to 3.0 m/s.
d) much less than 3.0 m/s.

Answer: a Difficulty: 2

58. A railroad car, of mass 200 kg, rolls with negligible friction on a horizontal track with a speed of 10 m/s. A 70-kg stunt man drops straight down a distance of 4.0 m, and lands in the car. How fast will the car be moving after this happens?

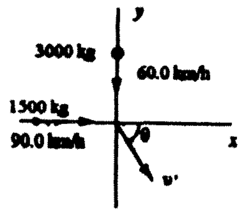
a) 2.8 m/s
b) 4.7 m/s
c) 7.4 m/s
d) 10 m/s

Answer: c Difficulty: 2

59. Two objects move on a level frictionless surface. Object A moves east with a momentum of 24 kg·m/s. Object B moves north with momentum 10 kg·m/s. They make a perfectly inelastic collision. What is the magnitude of their combined momentum after the collision?

a) 14 kg·m/s
b) 26 kg·m/s
c) 34 kg·m/s
d) Cannot be determined without knowing masses and velocities.

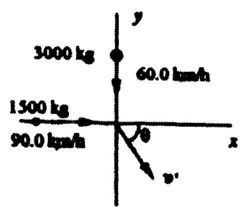
Answer: b Difficulty: 2



60. A 1500-kg car traveling at 90.0 km/h east collides with a 1000-kg car traveling at 60.0 km/h south. The two cars stick together after the collision. What is the speed of the cars after collision?

a) 8.33 m/s
b) 13.9 m/s
c) 17.4 m/s
d) 21.7 m/s

Answer: b Difficulty: 2



61. A 1500-kg car traveling at 90.0 km/h east collides with a 1000-kg car traveling at 60.0 km/h south. The two cars stick together after the collision. What is the direction of motion of the cars after collision?

a) 36.9° S of E
b) 36.9° E of S
c) 53.1° S of E
d) 53.1° E of S

Answer: c Difficulty: 2

62. A small bomb, of mass 10 kg, is moving toward the North with a velocity of 4.0 m/s. It explodes into three fragments: a 5.0-kg fragment moving west with a speed of 8.0 m/s; a 4.0-kg fragment moving east with a speed of 10 m/s; and a third fragment with a mass of 1.0 kg. What is the velocity of the third fragment? (Neglect air friction.)

a) zero
b) 40 m/s north
c) 40 m/s south
d) None of the above

Answer: b Difficulty: 2

63. Two objects collide and stick together. Kinetic energy

a) is definitely conserved.
b) is definitely not conserved.
c) is conserved only if the collision is elastic.
d) is conserved only if the environment is frictionless.

Answer: b Difficulty: 1

64. Two objects collide and bounce off each other. Kinetic energy

a) is definitely conserved.
b) is definitely not conserved.
c) is conserved only if the collision is elastic.
d) is conserved only if the environment is frictionless.

Answer: c Difficulty: 1

65. A 2.0 kg mass moves with a speed of 5.0 m/s. It collides head-on with a 3.0 kg mass at rest. If the collision is perfectly inelastic, what is the speed of the masses after the collision?

a) 10 m/s
b) 2.5 m/s
c) 2.0 m/s
d) 0, since the collision is inelastic.

Answer: c Difficulty: 1

66. A 3.0-kg object moves to the right at 4.0 m/s. It collides in a perfectly inelastic collison with a 6.0 kg object moving to the left at 2.0 m/s. What is the total kinetic energy after the collision?

a) 72 J
b) 36 J
c) 24 J
d) 0 J

Answer: d Difficulty: 2

67. A freight car moves along a frictionless level railroad track at constant speed. The car is open on top. A large load of coal is suddenly dumped into the car. What happens to the velocity of the car?

a) It increases.
b) It remains the same.
c) It decreases.
d) Cannot be determined from the information given.

Answer: c Difficulty: 1

68. A car of mass m, traveling with a velocity v, strikes a parked station wagon, whose mass is 2m. The bumpers lock together in this head-on inelastic collision. What fraction of the initial kinetic energy is lost in this collision?

a) 1/2
b) 1/3
c) 1/4
d) 2/3

Answer: d Difficulty: 2

69. A 2.0-kg mass moving to the east at a speed of 4.0 m/s collides head-on in a perfectly inelastic collision with a stationary 2.0-kg mass. How much kinetic energy is lost during this collision?

a) 16 J
b) 4.0 J
c) 8.0 J
d) zero

Answer: c Difficulty: 2

70. Three masses, 1.0 kg, 2.0 kg, and 3.0 kg, are located at (0,0), (1.0 m, 1.0 m), and (2.0 m, -2.0 m), respectively. What is the location of the center of mass of the system?

a) (1.3 m, 0.67 m)
b) (1.3 m, -0.67 m)
c) (-1.3 m, 0.67 m)
d) (-1.3 m, -0.67 m)

Answer: b Difficulty: 2

71. A 4.00-kg mass sits at the origin, and a 10.0-kg mass sits at x = + 21.0 m. Where is the center of mass on the x-axis?

a) +7.00 m
b) +10.5 m
c) +14.0 m
d) +15.0 m

Answer: d Difficulty: 1

72. Three masses are positioned as follows: 2.0 kg at (0, 0), 2.0 kg at (2.0, 0), and 4.0 kg at (2.0, 1.0). Determine the coordinates of the center of mass.

a) (0.50, 1.5)
b) (1.5, 0.50)
c) (2.5, 1.5)
d) (2.5, 0.50)

Answer: b Difficulty: 1

73. A 3.0-kg mass is positioned at (0, 8.0), and a 1.0-kg mass is positioned at (12, 0). What are the coordinates of a 4.0-kg mass which will result in the center of mass of the system of three masses being located at the origin, (0, 0)?

a) (-3.0, -6.0)
b) (-12, -8.0)
c) (3.0, 6.0)
d) (-6.0, -3.0)

Answer: a Difficulty: 2

74. Consider two unequal masses, M and m. Which of the following statements is false?

a) The center of mass lies on the line joining the centers of each mass.
b) The center of mass is closer to the larger mass.
c) It is possible for the center of mass to lie within one of the objects.
d) If a uniform rod of mass m were to join the two masses, this would not alter the position of the center of mass of the system without the rod present.

Answer: d Difficulty: 1

75. Tightrope walkers walk with a long flexible rod in order to

a) increase their total weight.
b) allow both hands to hold onto something.
c) lower their center of mass.
d) move faster along the rope.

Answer: c Difficulty: 2

76. Which of the following is a false statement?

a) For a uniform symmetric object, the center of mass is at the center of symmetry.
b) For an object on the surface of the earth, the center of gravity and the center of mass are the same point.
c) The center of mass of an object must lie within the object.
d) The center of gravity of an object may be thought of as the "balance point."

Answer: c Difficulty: 2

77. The center of mass of a two-particle system is at the origin. One particle is located at (3.0 m, 0) and has a mass of 2.0 kg. What is the location of the second mass of 3.0 kg?

a) (-3.0 m, 0)
b) (-2.0 m, 0)
c) (2.0 m, 0)
d) (3.0 m, 0)

Answer: b Difficulty: 2

78. A plane, flying horizontally, releases a bomb, which explodes before hitting the ground. Neglecting air resistance, the center of mass of the bomb fragments, just after the explosion

a) is zero.
b) moves horizontally.
c) moves vertically.
d) moves along a parabolic path.

Answer: d Difficulty: 2

79. A model rocket sits on the launch pad and its fuel is ignited, blasting the rocket upward. What happens to the center of mass of the rocket-fuel system?

a) It goes up.
b) It is stationary.
c) It follows the path of the rocket.
d) It follows the path of the fuel.

Answer: b Difficulty: 2

80. Two cars collide head-on on a level friction-free road. The collision was completely inelastic and both cars quickly came to rest during the collision. What is true about the velocity of this system's center of mass?

a) It was always zero.
b) It was never zero.
c) It was not zero zero, but ended up zero.
d) none of the above.

Answer: a Difficulty: 2