Momentum **Name** _____ **#:**____

1) Which of the following has the greater momentum?
A) a 50.0-g bullet traveling at 575 m/s or B) a 0.250-kg softball traveling at 115 m/s? Show the calculations supporting your answer.

$p = mv$

$m_1 = 50.0\,g = 0.050\,kg$ $m_2 = 0.250\,kg$

$v_1 = 575\,m/s$ $v_2 = 115\,m/s$

$p = 0.050\,kg \cdot 575\,m/s = 28.75\,kg\,m/s$

$p = 0.250\,kg \cdot 115\,m/s = 28.75\,kg\,m/s$

Answer same momentum

2) What must **change if the momentum of an object changes?** Velocity

3) **An egg is falling onto a road and another egg is falling onto a pillow.** Why did the **egg landing on the road break** and the **egg that landed on the pillow did not break?**
the pillow makes collision last longer [Δt] so F needed to stop will be lower for egg

4) **A moving bowling ball collides with a 7-pin** sitting in a bowling lane. **How does the momentum of each object change?**
Conservation of momentum, bowling ball will lose some momentum from slowing down in collision. pin will increase its momentum

5) Two identical carts are separated by a strong compressed spring. If the spring is released, **what happens to the momentum of the two carts?**
one cart will have an increase in positive momentum, & the other will have an increase in (-) momentum so their total p will = 0 kg m/s

6) A **2170-kg** truck has a velocity of **30.0 m/s to the** east. **What is the momentum** of the truck?

Formula **Set-Up with Units**

$p = mv$

$m = 2170\,kg$

$v = 30.0\,m/s$

$p = 2170\,kg \cdot 30.0\,m/s =$

Answer 65,100 kg m/s

7) A **25.5-kg** is coasting down a hill at a constant velocity of **5.72 m/s** in a **9.33-kg** wagon.

a) **What is the total momentum of the child and the wagon together?**

Formula **Set-Up with Units**

$p_{tot} = (m_1 + m_2)v$

$m_1 = 25.2\,kg$ $v = 5.72\,m/s$

$m_2 = 9.33\,kg$

$p_{tot} = (25.2\,kg + 9.33\,kg)5.72\,m/s$

Answer 197.5 kg m/s

b) **What is the momentum of the child?**

Formula **Set-Up with Units**

$p_C = mv$

$m_C = 25.2\,kg$

$v_C = 5.72\,m/s$

$p_C = 25.2\,kg \cdot 5.72\,m/s =$

Answer 144 kg m/s

8) A **275-g** Physics cart traveling to the west is slowed down uniformly from **5.15 m/s to 3.66 m/s in 3.50 s**.

a) **What constant force** acted on the car during this time?

Formula **Set-Up with Units**

$F = ?$ $F\Delta t = m\Delta v$ $F = \frac{0.275\,kg(3.66\,m/s - 5.15\,m/s)}{3.50\,s}$

$\Delta t = 3.50\,s$ $v_i = 5.15\,m/s$ $v_f = 3.66\,m/s$ $m = 275\,g = 0.275\,kg$

Answer $-0.117\,N$

b) **How far did the car travel** during the acceleration time?

Formula **Set-Up with Units**

$\Delta x = \frac{1}{2}(v_f + v_i)\Delta t$ $\Delta x = \frac{1}{2}(3.66\,m/s + 5.15\,m/s)3.50\,s$

Answer $15.42\,m$

9) A pitcher claims he can throw a **175-g** baseball with as much momentum as a speeding bullet. Assume that a **5.00-g** bullet moves at a speed of **6.55 x 10^2 m/s**. **What must the baseball's speed** be if the pitcher's claim is valid?

Formula **Set-Up with Units**

$m_{ba} = 175\,g = 0.175\,kg$ $p = m_{ba}v_{ba} = m_{bu}v_{bu}$

$m_{bu} = 0.005\,kg$

$v_{bu} = 6.55 \times 10^2\,m/s$

$v_{ba} = ?$ $v_{ba} = \frac{0.005\,kg \cdot 6.55 \times 10^2\,m/s}{0.175\,kg} =$

Answer $18.71\,m/s$

10. Kim holds a 2.0 kg air rifle loosely and fires a bullet of mass 1.0 g. The muzzle velocity of the bullet is 150 m/s. What is the recoil speed of the rifle?

$m_R = 2.0\,kg$ $(m_R + m_b)v_i = m_R v_R + m_b v_b$

$m_b = 1.0\,g = 0.001\,kg$ $v_i = 0$

$v_b = 150\,m/s$ $v_R = \frac{m_b v_b}{m_R} = \frac{0.001\,kg \cdot 150\,m/s}{2.0\,kg} =$ 0.075 m/s

$v_R = ?$

11. If the girl in the previous question holds the rifle tightly against her body, the recoil speed is less. Explain. Calculate the new recoil speed assuming the girl has a mass of 48 kg.

$m_g = 48\,kg$ $(m_R + m_b + m_g)v_i = (m_R + m_g)v_R + m_b v_b$

$v_R = \frac{m_b v_b}{(m_R + m_g)} = \frac{0.001\,kg \cdot 150\,m/s}{(2.0\,kg + 48\,kg)} = 0.003\,m/s$

12. In a freight yard a train is being put together from freight cars. An empty freight car, coasting at 10 m/s, strikes a loaded car that is stationary, and the cars couple together. Each of the cars has a mass of 3000 kg when empty, and the loaded car contains 12,000 kg of canned soda (a year's supply for the Physics class). With what speed does the combination of the two cars start to move?

$v_{1i} = 10\,m/s$ $m_c v_{1i} + (m_c + m_s)v_{2i} = (m_c + m_c + m_s)v_f$

$v_{2i} = 0\,m/s$

$m_c = 3000\,kg$ $\frac{3000\,kg \cdot 10\,m/s}{(3000\,kg + 3000\,kg + 12000\,kg)} = v_f = 1.67\,m/s$

$m_s = 12{,}000\,kg$

$v_f = ?$

13. **An astronaut** whose mass is 80. kg carries an empty oxygen tank with a mass of 10. kg. He throws the tank away from himself with a speed of 2.0 m/s. With what velocity does he start to move off into space?

$v_{ti} = 0\,m/s$ $(m_a + m_t)v_i = m_a v_{af} + m_t v_{tf}$

$m_a = 80\,kg$ $v_{af} = \frac{10\,kg \cdot 2.0\,m/s}{80\,kg} = 0.25\,m/s$

$m_t = 10\,kg$

$v_{tf} = 2.0\,m/s$

$v_{af} = ?$

14. A tennis player returns a 30. m/s serve straight back at 25. m/s, after making contact with the ball for 0.50 s. If the ball has a mass of 0.20 kg, what is the force she exerted on the ball?

$V_i = 30\ m/s$ $m = 0.20\ kg$ $F\Delta t = m\Delta V$ $F = \frac{0.20\ kg \cdot (-25\ m/s - 30\ m/s)}{0.50\ s} = -22\ N$ or $22\ N$

$V_f = -25\ m/s$ $F = ?$

$\Delta t = 0.50\ s$

If V_i is (−) & V_f is (+)

15. A 50. kg cart is moving across a frictionless floor at 2.0 m/s. A 70. kg boy, riding in the cart, jumps off so that he hits the floor with zero velocity.

a. What impulse did the boy give to the cart?

$\Delta p = ?$ $\Delta p = m\Delta V$ $\Delta p = 70\ kg\ (0\ m/s - 2.0\ m/s) = -140\ kg\ m/s$ or $-140\ N\cdot s$

$m = 70\ kg$

$V_i = 2.0\ m/s$ $V_f = 0\ m/s$

b. What was the velocity of the cart after the boy jumped?

$V_i = 2.0\ m/s$ $V_{fc} = ?$ $(m_b + m_c)V_i = m_b V_{fb} + m_c V_{fc}$

$m_b = 70\ kg$ $V_{fb} = 0\ m/s$

$m_c = 50\ kg$

$V_{fc} = \frac{(50\ kg + 70\ kg)2.0\ m/s}{50\ kg} =$ 4.8 m/s

50 kg

16. Two girls with masses of 50.0 kg and 70.0 kg are at rest on frictionless in-line skates. The larger girl pushes the smaller girl so that the latter rolls away at a speed of 10.0 m/s. What is the effect of the action on the larger girl? What is the impulse that each girl exerts on the other?

$m_s = 50\ kg$ $V_i = 0\ m/s$ $(m_s + m_L)V_i = m_s V_s + m_L V_L$

$m_L = 70\ kg$

$V_s = 10\ m/s$

$V_L = ?$

$V_L = \frac{50\ kg \cdot 10\ m/s}{70\ kg} = 7.14\ m/s$

$\Delta p = m\Delta V = 50\ kg\ 10\ m/s$

$\Delta p = 500\ kg\ m/s = 500\ N\cdot s$

17. A 2.0 kg melon is balanced on a bald man's head. His son shoots a 50.0 g arrow at it with a speed of 30.0 m/s. The arrow passes through the melon and emerges with a speed of 18.0 m/s. Find the speed of the melon as it flies off the man's head.

$m_m = 2.0\ kg$ $V_{mi} = 0\ m/s$ $m_a V_{ai} + m_m V_{mi} = m_a V_{af} + m_m V_{mf}$

$m_a = 50\ g = 0.050\ kg$ $V_{mf} = ?$

$V_{ai} = 30\ m/s$

$V_{af} = 18\ m/s$

$V_{mf} = \frac{(0.050\ kg\ 30\ m/s - 0.050\ kg\ 18.0\ m/s)}{2.0\ kg}$

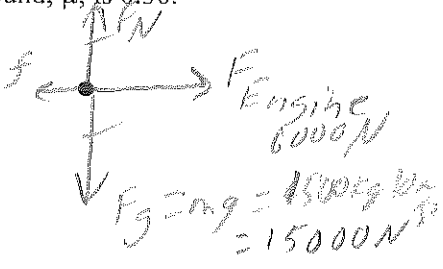
$V_{mf} = 0.3\ m/s$

Friction Review

18. You are driving a 1500-kg car, while sitting at a traffic light your friend pulls up next to you and you decide to show off how powerful mom's minivan is, when the light turns green you press the gas pedal to the floor. If the engine pushes your car forward with 6000 Newtons of force parallel to the ground to accelerate your minivan in the positive direction. The coefficient of friction of the sled with the ground, μ, is 0.30.

a) On the dot to the right, sketch a force diagram for the forces on the minivan, making sure to label all forces.

$\mu = 0.30$



b) Determine the force of friction acting on the minivan.

$f = \mu F_N$ $f = 0.30\ 15{,}000N = 4500N$

$f = \mu mg$

c) Calculate the acceleration of the minivan, making sure to show your work.

$\Sigma F = ma$ $F_{engine} - f = ma$

$a = \frac{6000N - 4500N}{1500\ kg} = 1\ \frac{N}{kg}$ or $1\ m/s^2$

Energy

1) When does a force do work on an object? When the F causes a displacement of the object

2) Besides applying a force, what other condition must occur ~~in order for~~ work to occur?

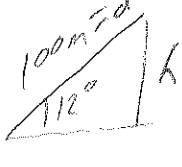
It must be displaced

3) A child pulls a toy across the floor. Is the work done on the toy positive or negative? Why?

Positive or Negative? the pull is in direction of Force

4) A hill is 100. m long and makes an angle of 12.0^0 with the horizontal. As a 50.0-kg jogger runs up the hill, how much work does gravity do on the jogger?

Formula



$W = \Delta PE = mg\Delta h$

$h = d \sin\theta = 100m \sin 12^0 = 20.8m$

Set-Up with Units

$m = 50kg \quad g = 10 m/s^2$

$W = 50kg\ 10m/s^2\ 20.8m$

cos 180°

Answer 10,400 J

5) A child moving at constant velocity carries a 2.0-N ice-cream cone 1.0 m across a level surface. Why is the net work done on the ice-cream cone zero?

the angle between F and d is 90° $\cos 90 = 0$ so No W done

6) A horizontal force of 250 N is applied to move a 55-kg television set across a 10.0-m level surface. What is the work done by the 250-N force on the television?

Formula

$F = 250N$
$d = 10.0m$
$m = 55kg \quad \theta = 0^0$

$W = Fd\cos\theta$

Set-Up with Units

$W = 250N \cdot 10.0m \cos 0^0$

Answer 2,500 J

7) A pencil falls from a desk to the floor. What energy form(s) is/are involved at the moment that the pencil leaves the desk?

pencil has PE due to gravity to start which changes to KE as it falls. Total energy = amount of PE it had to start

8) Illustrate by using numbers as examples, how the kinetic energy of a thrown ball would change if both the mass and the velocity of the ball were doubled.

EXAMPLE:

$KE = \frac{1}{2} m v^2$

$m = 2kg \quad v = 2m/s$

$KE = \frac{1}{2} 2kg (2m/s)^2 = 4J$

$KE = \frac{1}{2} 4kg (2m/s)^2 = 8J$

double mass doubles KE

$\frac{1}{2} 2kg (4m/s)^2 = 16J$

double $v = 4 \times KE$

triple $v = 9 \times KE$

$\frac{1}{2} 2kg (6m/s)^2 = 36J$

9) A 20.0-g coin, which has zero potential energy at rest, is dropped into a 10.0-m well. After the coin comes to a stop in the mud, what is its potential energy?

Formula

$m = 20.0g = 0.020kg$

$PE_i = 0$ J

$\Delta h = -10m$

$g = 10 m/s^2$

$PE = mgh$

Set-Up with Units

$PE = 0.020kg\ 10m/s^2\ -10m = -2J$

Answer -2 J

10) A plane designed for vertical takeoff has a mass of 8.0×10^3 kg. Find the net work done by all forces on the plane as it accelerates upward at 1.0 m/s^2 through a distance of 30.0 m after starting from rest.

Formula Set-Up with Units

$m = 8.0 \times 10^3 kg$ $F_{net} = ma$

$a = 1.0 m/s^2$ $W = F_{net} d \cos\theta$

$F_{net} = ?$ $W = (8.0 \times 10^3 kg)(1 m/s^2)(30.0 m)\cos 0^\circ =$

$g = 10 m/s^2$ $d = 30.0 m$ $\theta = 0^\circ$

Answer 2,400,000 J

11) What is the kinetic energy of an automobile with a mass of 1250 kg traveling with a speed of 11.0 m/s?

Formula Set-Up with Units

$KE = ?$ $KE = \frac{1}{2} m v^2$

$m = 1250 kg$ $= \frac{1}{2}(1250 kg)(11.0 m/s)^2 =$

$v = 11.0 m/s$

Answer 75,625 J

12) A child and sled with a combined mass of 50.0 kg slide down a frictionless hill. If the sled starts from rest and has a speed of 12.0 m/s at the bottom of the hill, what is the height of the hill?

Formula Set-Up with Units

$m = 50.0 kg$ $E_i = E_f$ $mgh = \frac{1}{2} m v^2$

$v = 12.0 m/s$ $PE = KE$ $h = \frac{1}{2}\frac{(12.0 m/s)^2}{10 m/s^2} =$

$h = ?$

$g = 10 m/s^2$

Answer 7.2 m

13) An 80.0-N box of clothes is pulled 20.0 m up a 30.0^0 ramp by a force of 115 N that points along the ramp. If the coefficient of kinetic friction between the box and ramp is 0.220, calculate the change in the box's kinetic energy.

Formula Set-Up with Units

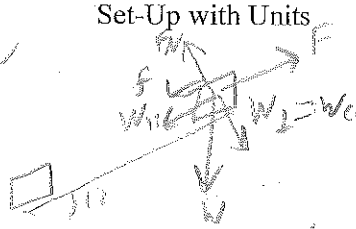
$W = 80.0 N$ $W_{\perp} = W \sin\theta$ $E_i = E_f$ $\Delta KE = Work$

$d = 20.0 m$ $W_{\perp} = 80 N \sin 30^\circ$ $W_{net} = Fd - fd = W_{\perp} d$

$\theta = 30.0^\circ$ $W_{\perp} = 40 N$ $Work = (115 N - 15.2 N - 40 N)(20 m)$

$F = 115 N$ $Work = 1196 J$

$\mu = 0.220$



$f = \mu F_N = \mu W \cos\theta$

$f = 0.220(80 N)\cos 30^\circ = 15.2 N$

Answer 1196 J

14) 2 A force does work on an object if a component of the force:

1) is perpendicular to the displacement of the object.
2) is parallel to the displacement of the object.
3) perpendicular to the displacement of the object moves he object along a path that returns to its starting position.
4) parallel to the displacement of the object along a path that returns to its starting position.

15) 1 Work is done when:

1) the displacement is not zero.
2) the displacement is zero.
3) the object is moved in one complete circle.
4) the object is moved along a path and returns to its starting position.

16) 4 If the net work is positive,
1) the object slows down and work is done by the object on another object.
2) the object slows down and the net force does work on the object.
3) the object speeds up and work is done by the object on another object.
4) the object speeds up and the net force does work on the object.

17) 3 A child pulls a toy car across the floor. What type of work is done?
1) No work is done because the movement is parallel to the applied force.
2) Negative Work
3) Positive Work

18) 3 The magnitude of the component of the force that does the work is 43.0 N. How much work is done on a bookshelf being pulled 5.00 m?
1) 129 J 2) 172 J 3) 215 J 4) 792 J

19) 2 A worker pushes a wheelbarrow with a horizontal force of 50.0 N over a level distance of 5.0 m. If a frictional force of 43 N acts on the wheelbarrow in a direction opposite to that of the worker, what net work is done on the wheelbarrow?
1) 7.0 J 2) 35 J 3) 215 J 4) 250 J

20) 1 The main difference between kinetic energy and potential energy is that
1) kinetic energy involves motion and potential energy involves position.
2) kinetic energy involves position and potential energy involves motion.
3) although both energies involve motion, only kinetic involves position.
4) although both energies involve position, only potential involves motion.

21) 4 Which of the following energy forms is stored in any compressed or stretched object?
1) potential energy 2) gravitational potential energy
3) kinetic energy 4) elastic potential energy

22) 2 As an object is lowered into a deep hole in the Earth, which of the following assumptions must be made in regard to the object's potential energy?
1) The potential energy increases.
2) The potential energy decreases.
3) The potential energy remains constant.
4) The potential energy increases and then decreases.

23) 4 Which of the following is the rate at which energy is transferred?
1) potential energy 2) kinetic energy
3) mechanical energy 4) power

24) A catcher "gives" with a baseball when catching it. If the baseball exerts a force of 475 N on the glove, so that the glove is displaced 10.0 cm, how much work is done by the ball?

Formula Set-Up with Units

$F = 475\ N$ $W = Fd\cos\theta$

$d = 10.0\ cm = 0.10\ m$ $W = 475\ N\ 0.10\ m\ \cos 180^\circ$ 180°

$W = ?$

Answer - 47.5 J

25) What is the kinetic energy of an automobile with a mass of 1500 kg traveling with a speed of 13.5 m/s?

Formula

$m = 1500\ kg$

$v = 13.5\ m/s$

$KE = ?$

Set-Up with Units

$KE = \frac{1}{2} m v^2$

$KE = \frac{1}{2}\ 1500\ kg \cdot (13.5\ m/s)^2 =$

Answer 136,687.5

b) How high above the ground would the automobile get if it was launched straight up?

Formula

$E_i = E_{sp} + KE$

$h = ?$

$g = 10\ m/s$

Set-Up with Units

$mgh = \frac{1}{2} m v^2$

$h = \frac{v^2}{2g}$

$h = \frac{(13.5\ m/s)^2}{(2 \cdot 10\ m/s^2)} =$

Answer 9.11 m