PHYSICS 11

NAME: Key

Energy & Momentum Review

Energy

1. A net force of 90.0 N does 45.0 J of work on a brick. What is the magnitude of the displacement of the brick? $W = F \cdot d$ $45\,J = (90.0)(d)$ $d = \frac{45}{90} = 0.5\,m$

2. How much work is done against gravity in lifting a 3.0 kg object through a distance of 40.0 cm ?

$W = \Delta E_p = mgh$
$= (3kg)(9.8 m/s^2)(.4m) = 11.8\,J \approx 12\,J$

3. What is the kinetic energy of a 60 kg athlete running 6.0 m/s?

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(60kg)(6)^2 = 1080\,J$

4. How would the kinetic energy of a moving object be affected if its velocity were doubled while the mass remains constant. pick some #'s for m and v or...

$\frac{1}{2}m(2v)^2 = \frac{1}{2}m(4v^2) = 4\left(\frac{1}{2}mv^2\right)$ 4 times greater

5. When an object is lifted 10 meters it gains a certain amount of potential energy. If the same object is lifted 20 m, its potential energy is ... doubled h becomes 2h
$E_p = mgh$

6. How much power is produced by a 60.0 kg person running up a 4.5 m high flight of stairs in 3.0 sec? $P = \frac{W}{t} = \frac{\Delta E_p}{t} = \frac{(60)(9.8)(4.5)}{3.0s} = 882\,W$

7. A machine with a power rating of 15.0 kW must complete a job requiring an expenditure of 1.5×10^5 J of energy. How long will it take to complete the job?

$P = \frac{W}{t}$, $15000\,W = \frac{1.5\times10^5\,J}{t}$, $t = \frac{1.5\times10^5\,J}{15000\,W} = 10s$

8. A 0.50 kg block is sliding across a table top with an initial velocity of 0.20 m/s. It slides to rest in a distance of 0.70 m. Find the average friction force that slowed its motion.

Work to stop is $\Delta E_K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$
$= \frac{1}{2}(.5)(0)^2 - \frac{1}{2}(.5)(.2)^2$
loses energy $= -.01\,J$

$W = F \cdot d$
$-0.01\,J = F(.7m)$
$F = -.014\,N$ ← opposes motion

9. A force of 1.50 N acts on a 0.20 kg cart so as to accelerate it along an air track. How fast is the cart going after acceleration from rest through 30 cm if friction is negligible?

$W = \Delta E$ $W = F \cdot d$
$= (1.5N)(.3m)$
$= .45\,J$

$W = \Delta E$
$.45\,J = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$
$.45\,J = \frac{1}{2}(.2)v_f^2 - 0$
$v_f = 2.12\,m/s$

10. A force of 35 N accelerates a 2.0 kg object from rest for a distance of 5.0 m along a level frictionless surface, the force then changes to 25 N and acts for and additional 3.0 m.
    a) What is the final kinetic energy of the object?
    b) How fast is it moving?

a) $W = \Delta E_K$

$W = F_1 d + F_2 d_2$

$= (35)(5) + (25)(3) = 250\text{ J}$

$\Delta E_K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_0^2$

$250\text{ J} = \frac{1}{2}(2) v_f^2 - 0$

$v_f = 15.8\text{ m/s}$

11. A pole vaulter of mass 75 kg just clears 5.3 m. How fast was he running the instant before his jump, assuming the height he jumps is due entirely to his kinetic energy?

$E_b = E_a$

$E_K + E_P = E_K + E_P + E_H$ (0, 0, 0)

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

$\frac{1}{2}(75) v^2 = (75)(9.8)(5.3)$

$v^2 = 104$

$v = 10.2\text{ m/s}$

12. How much energy has been lost due to frictional heating by the air when an 0.08 kg object attains a speed of 5.0 m/s while free falling 1.5 m from rest?

$E_b = E_a$

$E_K + E_P = E_K + E_P + E_H$ (0, 0, 0)

$E_P = E_K + E_H$

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

$(.08)(9.8)(1.5) = \frac{1}{2}(.08)(5)^2 + E_H$

$1.176 = 1.0 + E_H$

$E_H = .176\text{ J}$

13. Betty weighs 420 N and is sitting on a playground swing seat that hangs 0.40 m above the ground. Tom pulls the swing back and releases it when the seat is 1.00 m above the ground.
    a) How fast is Betty moving when the swing passes through its lowest position? (no friction)
    b) If Betty moves through the lowest point at 2.0 m/s, how much work was done on the swing by friction?

$m = 43\text{ kg}$

$E_b = E_a$

$E_K + E_P = E_K + E_P + E_H$

$(43)(9.8)(1.0) = \frac{1}{2}(43)(v^2) + (43)(9.8)(.4)$

$420 = 21.5 v^2 + 169$

$v = 3.42\text{ m/s}$

$E_K + E_P + E_H = E_K + E_P + E_H$

$(43)(9.8)(1.0) = \frac{1}{2}(43)(2)^2 + (43)(9.8)(.4) + E_H$

$420 = 86 + 169 + E_H$

$E_H = 165\text{ J}$

14. A truck of mass 4.0×10^3 kg travelling at 20 m/s is brought to a stop by a constant braking force of 5.0×10^3 N. How far does the truck travel while the brakes are applied?

$W = \Delta E_K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_0^2$

$= 0 - \frac{1}{2}(4.0 \times 10^3\text{ kg})(20)^2$

$= 8.0 \times 10^5\text{ J}$

$W = F \cdot d$

$8 \times 10^5\text{ J} = (5.0 \times 10^3\text{ N})(d)$

$d = 160\text{ m}$

15. A 1000 kg car travelling at an unknown velocity begins to head down a 30 m high hill. Exactly halfway down the hill a police radar trap clocks the car travelling at 30 m/s. Neglecting friction, how fast was the car travelling at the top of the hill?

$E_B = E_a$

$E_K + E_P = E_K + E_P + E_H$ (0)

$\frac{1}{2}(1000) v^2 + (1000)(9.8)(30\text{m}) = \frac{1}{2}(1000)(30)^2 + (1000)(9.8)(15\text{m})$

$500 v^2 + 294000\text{ J} = 450000\text{ J} + 147000$

$500 v^2 = 303000$

$v^2 = 606$, $v = 24.6\text{ m/s}$

16. How much heat would be needed to warm 1.6 kg of ice from -15°C up to its melting point of 0.0°C?

$E_h = mc\Delta T$
$= (1.6kg)(2060 \frac{J}{kg°C})(15) = 4.94 \times 10^4 J$

17. The specific heat capacity of ice is ~~2040~~ 2060 J/kg°C. If 400 kJ of heat energy is applied to 10 kg of -25° C ice what temperature is it raised to?

$E_h = mc\Delta T$
$400000 J = (10kg)(2060)\Delta T$
$\Delta T = 19.4°C$

$T_f = -25°C + 19.4°C$
$= -5.6°C$

18. Determine the heat energy required to melt 2.0 kg of ice at -10 °C to 30 °C water. (c_{water} = 4180 J/kg°C, c_{ice} = 2060 J/kg°C, H_f = 3.34 x 10^5 J/kg, H_v = 2.26 x 10^6 J/kg)

ice -10°C → 0°C
$E_h = (2.0)(2060)(10)$
$= 41200 J$

ice ⇒ water
$E_h = mh_f$
$= (2kg)(3.34 \times 10^5 J/kg)$
$= 6.68 \times 10^5 J$

water 0°C → 30°C
$E_h = (2)(4180)(30)$
$= 250800 J$

total = $9.6 \times 10^5 J$

19. The diesel engine of an automobile runs at 38% efficiency. If the cars output energy is 76 kJ, how much energy is contained in the gas tank?

$Eff = \frac{useful\ out}{in} \times 100\%$, $38\% = \frac{76kJ}{in} \times 100\%$

$in = \frac{76}{.38} = 200 kJ$

Momentum

1. An object is pushed with a force of 6.0 N for 0.5s. What impulse is given to it?

$I = F \cdot \Delta t$
$= (6N)(.5s)$
$= 3.0 N \cdot s$

2. What impulse produces a velocity change of 4.0 m/s in a 12.5 kg mass?

$I = \Delta p = m \cdot \Delta v$
$= (12.5kg)(4)$
$= 50 kg\,m/s$

3. A freight car with a mass of 40,000 kg is rolling along a level track at 1.40 m/s.
   a) If the largest braking force that could be applied is 500 N, how long would it take to stop the car?

$\Delta p = m\Delta v = F \cdot \Delta t$
$(40000)(1.4) = 500N(\Delta t)$
$\Delta t = 112 s$

   b) How far would the car move before it stopped?

$W = F \cdot d = \Delta E_K$
$(500N)\,d = \frac{1}{2}(40,000)(1.4)^2$
$d = 78.4 m$

4. What average force will stop a hammer with a momentum of 48 N.s in 0.030s?

$I = F \cdot \Delta t$ $\quad F = 1600\,N$

$48\,N.s = F(.030s)$

5. A 5000 kg box car runs into a stationary 8000 kg tank car at 3.5 m/s. They connect together and move off down the track. How fast will they travel?

$P_b = P_a$

$m_1v_1 + m_2v_2 = (m_1+m_2)v_f$ $\quad v_f = 1.35\,m/s$

$(5000)(3.5)+(8000)0 = (13000)\,v_f$

$17500 = 13000\,v_f$

6. A 0.20 kg golf ball moving at 80 m/s hits a 10.0 kg watermelon at rest on a frictionless table and sticks in it. How fast does the watermelon move?

$P_b = P_a$

$m_1v_1 + m_2v_2 = (m_1+m_2)v_f$ $\quad v_f = 1.57\,m/s$

$(.2kg)(80)+(10)(0) = (10.2)\,v_f$

$16 = 10.2\,v_f$

7. A 6.0 kg object at rest explodes into two parts. If part A has mass 2.0 kg and a velocity of 18.0 m/s right, what is the velocity of part B?

$P_b = P_a$

$mv = m_1v_1 + m_2v_2$ $\quad v_2 = -9\,m/s = 9\,m/s$ left

$(6)0 = 2(18) + 4(v_2)$

8. A 40.0 kg object moving to the right at a velocity of 2.0 m/s collides with a 30.0 kg object moving to the left at a velocity of 5.0 m/s. If the 40.0 kg object moves to the left at a velocity of 2.0 m/s, what is the velocity of the 30.0 kg object? Is this an elastic or inelastic collision?

right +
left −

$P_b = P_a$

$m_1v_1 + m_2v_2 = m_1v_{1f} + m_2v_{2f}$

$(40)(2) + (30)(-5) = (40)(-2) + 30(v_f)$

$80 + (-150) = -80 + 30v_f$

$-70 = -80 + 30v_f$

$10 = 30v_f$

$v_f = .33\,m/s$

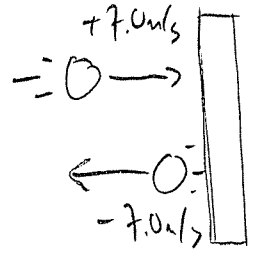
$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$

$80J + 375J = 80J + 1.6J$

$E_{K_b} \neq E_{K_a}$

inelastic

9. A 0.40 kg ball moving at 7.0 m/s rebounds off a wall with the same speed. What is the impulse given to the wall.



$I = m\Delta v$

$= (.4kg)(-7m/s - 7m/s)$

$= (.4kg)(14m/s)$

$= 5.6\,kg\,m/s$

10. A professional golfer can give a golf ball (mass 0.175 kg) an initial velocity of 110 m/s. If the ball is in contact with the club for 0.040 s, calculate the average force applied to the ball when it is hit.

$I = m\Delta v = F\Delta t$

$(.175kg)(110m/s) = F(.040s)$

$F = 480\ N$

11. A 6.0 kg ball is given an initial velocity of 10 m/s and then is allowed to roll along a floor. A frictional force of 3.0 N opposes its motion. For what length of time will it roll before stopping?

$I = m\Delta v = F\Delta t$ $\qquad t = 20s$

$(6kg)(0-10) = (-3.0N)\Delta t$

$-60 = -3t$

12. What is the momentum of a 80 kg runner who covers 1000 m in 300s running at constant velocity?

$v = \frac{d}{t} = \frac{1000m}{300s} = 3.3m/s$ $\qquad p = mv$

$p = (80)(3.3)$

$= 267\ kgm/s$

13. If an object with a velocity of 30 m/s has the same momentum as that of a 15 kg mass having a velocity of 20 m/s, the mass of the object is…

$p_1 = mv$

$= (15kg)(20m/s)$

$= 300kgm/s$

$p_2 = mv$

$300 = m(30)$

$m = 10\ kg$

14. A rubber ball moving at 5.0 m/s collides with a stationary ball of double the mass. After the collision the ball that was initially moving at 5.0 m/s now has a velocity of 2.0 m/s in the opposite direction. What is the velocity of the ball that was originally stationary.

$m_2 = 2m_1$

$p_b = p_a$

$m_1v_1 + m_2v_2 = m_1v_{1f} + m_2v_{2f}$

$m(5) + 2m(0) = m(-2) + 2mv_f$

$5m = -2m + 2mv_f$

$\frac{7m}{2m} = \frac{2mv_f}{2m}$

$3.5 = v_f$

$v_f = 3.5\ m/s$

15. An astronaut whose total mass is 80 kg ejects 35.0 grams of gas from his propulsion pack at a speed of 50 m/s. His recoil speed is… explosion

$p_b = p_a$

$mv = m_1v_1 + m_2v_2$

$0 = (.035kg)(50) + 80kg\ v_2$

$0 = 1.75 + 80v_2$

$v_2 = -0.022m/s$

16. A 8000 kg railroad car is coasting on a track at a constant velocity of 10 m/s. As the car coasts under a loading ramp, a 500 kg bale of hay is dropped into it. What is the velocity of the car containing the hay is changed to?

$P_b = P_a$

$m_1v_1 + m_2v_2 = (m_1+m_2)v$ $\quad v = 9.4\ m/s$

$(8000)(10) + (500)(0) = (8500)v$

$80000 = 8500v$

17. A student whose mass is 70.0 kg is on roller skates. The student throws a 5.0 kg medicine ball horizontally away from himself with a speed of 6.0 m/s. Neglecting friction, find the speed of the student after he throws the ball.

$P_b = P_a$

$mv = m_1v_1 + m_2v_2$

$(75)(0) = (5)(6) + (70)v_2$

$0 = 30 + 70v_2$

$-30 = 70v_2$

$v_2 = -.43\ m/s$

Energy Answers:

1. 0.5 m
2. 12 J
3. 1080 J
4. 4 times greater
5. double
6. 882 W
7. 10.0 s
8. 0.014 N
9. 2.1 m/s 250 J
10. ~~240~~ J, ~~15.5~~ ~~295~~ m/s 15.5 m/s
11. 10.2 m/s
12. 0.20 J
13. 3.43 m/s, 166 J
14. 160 m
15. 24.6 m/s
16. ~~50.4~~ 49.4 kJ
17. ~~-5.4°C~~ -5.6
18. 9.6×10^5 J
19. 200 kJ

Momentum Answers:

1. 3.0 Ns
2. 50 kgm/s
3. 112s, 78.4 m
4. 1600 N
5. 1.35 m/s
6. 1.57 m/s
7. -9 m/s, or 9 m/s left
8. 0.33 m/s
9. 5.6 kgm/s
10. 480 N
11. 20 s
12. 267 kgm/s
13. 10 kg
14. 3.5 m/s
15. -0.02 m/s
16. 9.4 m/s
17. -0.43 m/s