PHYSICS 11

NAME: _____

Review 3

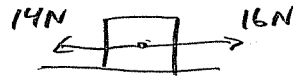
Newton's Laws and Free Body Diagrams

1. An unbalanced force of 72 N acts on a 8.0 kg object. If the object was initially at rest what will be its velocity after 4.0 s?

$F_{net} = ma$ $\quad a = 9 m/s^2$ $\quad V_f = V_0 + at$

$72N = (8kg)(a)$ $\quad = 0 + (9 m/s^2)(4s)$ $\quad \boxed{V_f = 36 s}$

2. A 16 N force pushes on an object towards the east. A 14 N force pushes on the same object towards the west. (a) What is the net force on the object? (b) If the object is observed to accelerate at 0.50 m/s^2, what is the object's mass?



$F_{net} = 16N - 14N$ $\quad = \boxed{2N}$

$F_{net} = ma$ $\quad m = \frac{2N}{.5}$

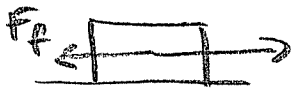
$2N = m(.5 m/s^2)$, $\quad = \boxed{4 kg}$

3. A 24 kg mass is observed to accelerate from rest at 4.0 m/s^2 towards the east. The applied force acting on the mass is 120 N.

(a) What is the net force acting on the mass? $F_{net} = ma$

$= (24kg)(4.0) = \boxed{96 N}$

(b) What is the force of friction acting on this mass?



$F_{net} = 120N - F_f$, $\quad F_f = 120N - 96N$

$96N = 120N - F_f$ $\quad = \boxed{24N}$

(c) If, when the speed of the object has reached 12 m/s the applied force is removed, how long will it take the object to stop?

$F_{net} = F_f$ $\quad a = \frac{-24N}{24kg} = -1 m/s^2$ $\quad V_f = V_0 + at$

$ma = 24N$ $\quad 0 = 12 + (-1 m/s^2)(t)$

$-12 = -1t$, $\quad \boxed{t = 12 s}$

(d) How far will the object have traveled before it stops?

$V_f^2 = V_0^2 + 2ad$ $\quad -144 = -2d$

$0 = 12^2 + 2(-1)d$ $\quad d = \boxed{72 m}$

4. A 4.0 kg object accelerates from rest traveling 24 m in the first 4.0 s. What is the net force exerted on this object during acceleration?

$d = V_0 t + \frac{1}{2} a t^2$ $\quad 24 = 8a$ $\quad F_{net} = ma$

$24m = 0 + \frac{1}{2} a (4s)^2$ $\quad a = 3 m/s^2$ $\quad = (4kg)(3)$

$= \boxed{12 N}$

5. A 50 kg bucket is being lifted by a rope. The rope is guaranteed not to break if the tension is 500 N or less. The bucket started at rest, and after being lifted 3.0 m, it is moving at 3.0 m/s. Assuming that the acceleration is constant, is the rope in danger of breaking?

$V_f^2 = V_0^2 + 2ad$ $\quad a = 1.5 m/s^2$

$3.0^2 = 0 + 2a(3)$

$9 = 6a$

$F_{net} = F_T - F_g$

$F_T = F_{net} + F_g$

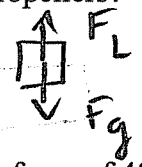
$= ma + mg$

$= (50)(1.5) + (50)(9.8)$

$= \boxed{565 N} > 500 N$

Could break.

6. A 4500 kg helicopter accelerates upward at 2.0 m/s^2. What lift force is exerted by the air on the propellers?



$F_{net} = F_L - F_g$

$ma = F_L - F_g$

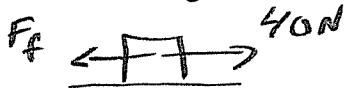
$F_L = ma + mg$

$= (4500)(2) + (4500)(9.8)$

$= \boxed{53100\ N}$

7. A force of 40.0 N accelerates a 5.0 kg block at 6.0 m/s^2 along a horizontal surface.

a. How large is the frictional force?



$F_{net} = 40N - F_f$

ma

$5(6) = 40N - F_f$

$F_f = \boxed{10N}$

b. What is the coefficient of friction?

$F_f = \mu F_N$

$= \mu mg$

$\frac{F_f}{F_N} = \mu$

$\frac{10}{(5)(9.8)} = .20$

8. A 22 kg sled is being pulled up a slope at a constant speed of 3.0 m/s. What is the net force on the sled if the applied force is 17 N?

$F_{net} = 0$ if constant speed.

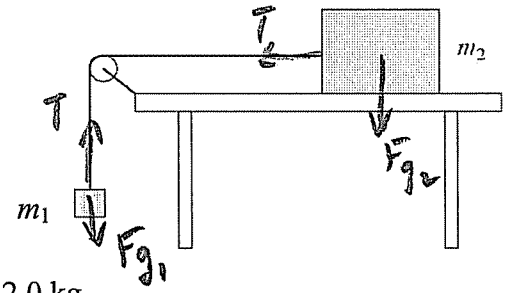
9. Find the acceleration of the system if $m_1 = 0.50$ kg and $m_2 = 2.0$ kg

$F_{net} = F_{g1}$

$(m_1 + m_2)a = m_1 g$

$2.5a = .5(9.8)$

$a = \frac{.5(9.8)}{2.5} = \boxed{1.96\ m/s^2}$



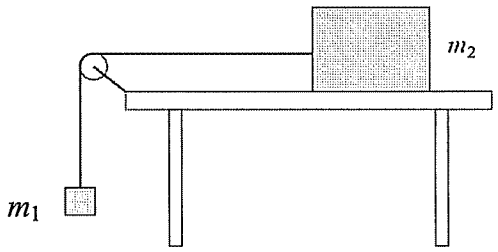
10. Find the acceleration of the system if $m_1 = 4.0$ kg and $m_2 = 2.0$ kg

$F_{net} = F_{g1}$

$(m_1 + m_2)a = m_1 g$

$6a = 4(9.8)$

$a = \frac{4(9.8)}{6} = 6.53\ m/s^2$



11. Find the acceleration of the pulley system

$F_{net} = F_{g2} - F_{g1}$

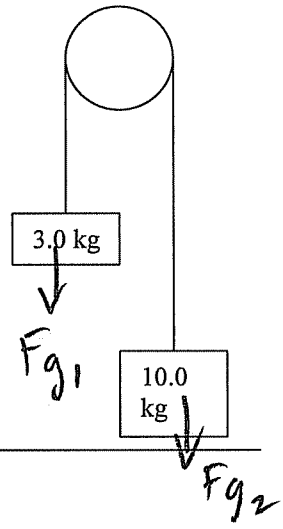
$(m_1 + m_2)a = m_2 g - m_1 g$

$13a = 10(9.8) - 3(9.8)$

$13a = 68.6\ N$

$a = \frac{68.6\ N}{13}$

$= 5.27\ m/s^2$



Work, Energy and Power

12. A student lifts a box of books that weighs 185 N. The box is lifted 0.800 m. How much work does the student do on the box?

$W = \Delta E = \Delta E_p = E_f - E_0 = mgh_f - mgh_0 = (185N)(.8) - 0 = \boxed{148\,J}$

13. Two students together exert a force of 878 N in pushing a car 28 m.

a. How much work do they do on the car?

$W = F \cdot d = (878N)(28m) = \boxed{24600\,J}$

b. If the force were doubled, how much work would they so pushing the car the same distance?

$W = (1756)(28m) = \boxed{49200\,J}$ (double)

14. A 0.220 kg ball falls 2.9 m. How much work does the force of gravity do on the ball?

$W = F_g \cdot d = (.220)(9.8)(2.9m) = \boxed{5.68\,J}$

15. 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?

$P = \frac{W}{t} = \frac{mgh}{t} = \frac{(60)(9.8)(4.5m)}{3.0} = \boxed{882\,W}$

16. An electric motor develops 89 kW of power as it lifts a loaded elevator 15.5 m in 42 s. How much force does the motor exert?

$P = \frac{W}{t} = \frac{F \cdot d}{t}$, $89000 = \frac{F(15.5m)}{42}$, $\boxed{F = 2.4 \times 10^5\,N}$

17. A machine does 4500 J of work in 60 s. If the motor is supplied with 120 W of electric power to run, how efficient is it?

$Eff = \frac{useful\ out}{in}$, output power $= \frac{W}{t} = \frac{4500J}{60s} = 75W$

$Eff = \frac{75W}{120W} = \boxed{.625 = 62.5\%}$

18. A rifle can fire a 38.0 g bullet at a speed of 825 m/s.

a. What is the bullet's kinetic energy as it leaves the gun? $E_K = \frac{1}{2}mv^2 = \frac{1}{2}(.038)(825)^2 =$

b. What work is done on the bullet when it is fired?

$W = \Delta E = E_{K_f} - E_{K_0} = 13000J - 0 = \boxed{13000J}$ $\boxed{E_K = 13000\,J}$

c. If the work is done over the barrel of the gun which is 0.60 m long, what was the average force applied to the bullet? $W = F \cdot d$, $13000J = F(.6)$, $\boxed{F = 2.17 \times 10^4\,N}$

19. A cannonball (m = 45 kg) is shot from the ground to a height of 425 m.

a. What is the gravitational potential energy of the cannonball at this height? $E_p = mgh = (45)(9.8)(425) = \boxed{1.9 \times 10^5\,J}$

b. What is the change in the potential energy when the cannonball falls to a height of ~~200 m~~?

$\Delta E_p = E_{p_f} - E_{p_0} = (45)(9.8)(200) - 1.9 \times 10^5\,J = \boxed{-9.9 \times 10^4\,J}$ - means loss

20. A bike rider approaches a hill at a speed of 7.7 m/s. The mass of the bike ~~and rider is 88 kg~~.

a. What is the kinetic energy of the system? $\frac{1}{2}mv^2 = \frac{1}{2}(88)(7.7)^2 = 2600\ J$

b. Assuming no friction, how far will the bike coast up the hill?

$E_b = E_a$ $\quad 2600 = mgh$ $\quad h = \frac{2600}{88(9.8)} = 3.0m$

$E_K = E_P$

21. How much heat is absorbed by 70.0 g of copper when its temperature is raised from 25.0°C to 75.0°C? (*c* for copper = 385 J/kg/°C)

$E_h = m \cdot C \cdot \Delta T = (.070kg)(385\ \frac{J}{kg\ C})(75-25) = 1350\ J$

22. 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.

$W = \Delta E$ $\quad F_f(.7) = 0 - \frac{1}{2}(.5kg)(.2)^2$ $\quad F_f = .014\ N$

$F_f \cdot d = E_{K_f} - E_{K_a}$

23. 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?

$E_H = .176\ J$

$E_b = E_a$ $\quad mgh = \frac{1}{2}mv^2 + E_H$

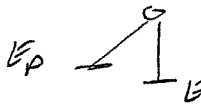
$E_K + E_P = E_K + E_H + E_P$ $\quad (.08)(9.8)(1.5) = \frac{1}{2}(.08)(5)^2 + E_H$

$1.176 = 1 + E_H$

24. 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?

$F_g = 420N = mg$ $\quad m = 43kg$



$E_b = E_a$ $\quad mgh = \frac{1}{2}mv^2$

$E_P = E_K$ $\quad (420)(.6m) = \frac{1}{2}(43)v^2$ $\quad v = 3.4m/s$

b) If Betty moves through the lowest point at 2.0 m/s, how much work was done on the swing by friction?

$E_b = E_a$ $\quad mE_p - E_K = E_H$ $\quad (420)(.6) - \frac{1}{2}(43)(2)^2$

$E_P = E_K + E_H$ $\quad mgh - \frac{1}{2}mv^2 = E_H$ $\quad 166J = E_H$

Momentum and Impulse

25. A 0.144 kg baseball is pitched horizontally at 38.0 m/s. After the bat hits it, it moves at the same speed, but in opposite direction.

a. What was the momentum of the ball before it hit the bat? After it hit the bat?

$P_b = mv = (.144)(38) = 5.5\ kg\,m/s$ $\quad P_a = (.144)(-38) = -5.5\ kg\,m/s$

b. What was the change in momentum of the ball?

$\Delta P = P_f - P_0 = -5.5 - 5.5 = -11.0\ kg\,m/s$

c. What was the impulse delivered by the bat?

$I = \Delta p = -11.0\ kg\,m/s$

d. If the bat and ball were in contact for 80.0 ms (milliseconds), what was the average force the bat exerted on the ball?

$I = F \cdot \Delta t$

$-11 = F(.08s)$, $\quad F = -138.N$

↑ opposite direction.

26. A 35.0 g bullet moving at 475 m/s strikes a 2.5 kg block of wood at rest. The bullet passes through the block, leaving at 275 m/s. How fast is the block moving when the bullet leaves?

$P_b = P_a$ $\quad (.035)(475) + (2.5)(0) = (.035)(275) + 2.5 v_f$

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$ $\quad 16.6 + 0 = 9.6 + 2.5 v_f$

$7 = 2.5 v_f$

27. What is the momentum of a bird of mass 22 g traveling at 11 m/s?

$v_f = 2.8$ m/s

$p = mv$

$= (.022)(11) = .242$ kg m/s

28. A child throws a rock of mass 5.40 kg horizontally from a canoe with velocity of 10.0 m/s. This causes the canoe to slip backwards as the rock flies forward. Calculate the resulting velocity of the canoe, assuming it was initially at rest. The mass of the child is 25.0 kg and the mass of the canoe is 55.0 kg.

$P_b = P_a$ $\quad 0 = (5.4)(-10 \text{ m/s}) + 80 v_f$

$mv = m_1v_1 + m_2v_2$ $\quad 54 = 80 v_f$, $v_f = .675$ m/s

29. An open railroad car of mass 11 000 kg travels alone on a level frictionless track with a constant velocity of 18.0 m/s. A 6 500 kg load is dropped onto the car. What will its new velocity be?

$P_b = P_a$ $\quad (11000)(18) + 6500(0) = (17500) v_f$

$m_1v_1 + m_2v_2 = (m_1 + m_2) v_f$ $\quad v_f = 11.3$ m/s

30. A golf ball of mass 0.0450 kg is hit off the tee at a speed of 50.0 m/s. The golf club was in contact with the ball for 0.00500 s. Find (a) the impulse on the golf ball, and (b) the force exerted on the ball by the club.

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

$= (.045)(50)$ $\quad 2.25 = F(.005)$

$I = 2.25$ N·s $\quad F = 450$ N

36 m/s
2 N 4.0 kg
96 N 24 N 12 s
72 m
12 N

F_{net} is zero

882 W

0.014 N
0.20 J
v = 3.43 m/s
W = 166 J
p= 0.24 kg•m/s
v = 0.68 m/s
v = 11.3 m/s
2.25 N•s, 450 N