Physics 211, Fall 2008
Quiz 4, Form: A

Name: KEY

Date: ______________________

Section 1. Multiple Choice

1. How much electrical energy does a 100-W light bulb use in 1 hour?
   (a) 100 J
   (b) 6000 J
   (c) 3600 J
   (d) 3.6×10^5 J
   (e) 0.028 J

   $P = \frac{\Delta E}{\Delta t}$

   $\Delta E = P\Delta t = (100 \frac{J}{s})(1 h)(\frac{3600 s}{h}) = 3.6 \times 10^5 J$

2. You use a spring-loaded dart gun to shoot a dart straight upward into the air. The dart's mass is 0.01 kg, and the stiffness of the spring is 100 N/m. If you initially compress the spring 0.1 m and shoot the dart from rest, what will be the peak height of the dart (above where it is launched)?
   (a) 50 m
   (b) 3.1 m
   (c) 5.1 m
   (d) 2.6 m
   (e) 1.0 m

   @ peak: $y_i = 0$, $y_f = ?$, $v_i = 0$, $v_f = 0$, $x_i = 0.1$, $x_f = 0$

   $E_i = E_f$ so $\frac{1}{2}kx_i^2 = mgy_f$, $y_f = \frac{\frac{1}{2}(100)(0.1)^2}{(0.01)(9.8)} = 5.1 m$

3. Suppose that you are driving your car at a speed v. If you double your speed, your kinetic energy
   (a) increases by a factor of 2
   (b) increases by a factor of 4.
   (c) increases by a factor of 8.
   (d) increases by a factor of $\sqrt{2}$.
   (e) remains constant.

   $KE = \frac{1}{2}mv^2$, $KE \propto v^2$, $(2v)^2$ gives $4v^2$

4. If there are no energy inputs and outputs, then the system is considered to be
   (a) a closed system.
   (b) a open system.
   (c) neither of the above because it could be either an open or a closed system.

   $E_i = E_f$

5. A skater has a mass of 50 kg and a speed of 1.4 m/s. What is her kinetic energy?
   (a) 25 J
   (b) 49 J
   (c) 70 J
   (d) 98 J
   (e) 490 J

   $KE = \frac{1}{2}(50)(1.4)^2 = 49 J$

6. While ice skating in a pairs competition, a man does 200 J of work on his partner as he pulls her on the ice and makes her speed up. If her mass is 50 kg and if her initial speed is 1.4 m/s, what is her final speed? (Assume she travels horizontally on the ice so that all of the work on her goes into changing her kinetic energy.)
   (a) 8.0 m/s
   (b) 2.8 m/s
   (c) 3.2 m/s
   (d) 2.0 m/s
   (e) 4.2 m/s

   E_i + inputs and outputs $= E_f$

   $\frac{1}{2}mv_i^2 + 200 J = \frac{1}{2}mv_f^2$

   $49 J + 200 J = \frac{1}{2}(50)v_f^2$

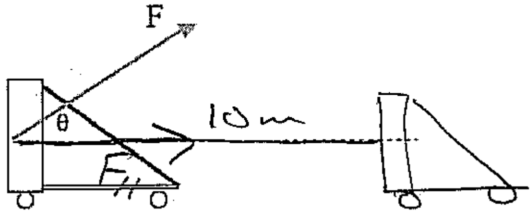
   $v_f^2 = \frac{249 J}{25 kg}$

   $v_f = 3.16 \frac{m}{s}$

7. While exercising, you do 250 calories of work on the exercise bike in a time interval of 20 minutes. What is your power in joules per second, or watts? (Note: 1 cal = 4.184 J.)
   (a) 0.87 W
   (b) 12.5 W
   (c) 0.21 W
   (d) 52 W
   (e) 17 W

   $P = \frac{\Delta E}{\Delta t} = \frac{250 cal}{20 min} = (12.5 \frac{cal}{min})(\frac{1 min}{60 s})(\frac{4.18}{1 cal}) = 0.87 \frac{J}{s}$

8. A football player pushes the training sled shown below. He pushes with a force of 600 N at an angle of 30° with respect to the +x axis. The sled moves 10 m in the +x direction.



How much work did he do on the training sled?

(a) 520 J
(b) 600 J
(c) 3000 J
(d) 5200 J
(e) 6000 J

$W = F_{\parallel}|\Delta\vec{r}|$
$= 600\cos(30°)(10\text{ m})$
$= 5196\text{ J}$

9. Suppose that the total work done on a system is −100 J. Did the system's energy increase, decrease, or remain constant as a result of work done on the system?

(a) increase
(b) decrease
(c) remain constant

negative work is an output

10. It takes 3 N to stretch a certain spring 15 cm. How much force is needed to stretch it twice as far, 30 cm?

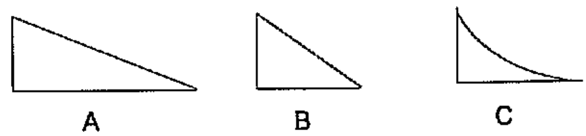
(a) 3 N
(b) 1.5 N
(c) 12 N
(d) 4.2 N
(e) 6 N

$F = kx$ Hooke's Law
2x requires 2F

11. What is the necessary condition for the momentum of a system to be conserved?

(a) The net external force on the system must equal zero.
(b) The kinetic energy of the system must be conserved.
(c) The objects in the system must not make contact with each other.

12. You do three experiments. In each case, you release a ball from rest from the top of a ramp, and you measure its speed at the bottom.



For which ramp will the ball have the greatest speed at the bottom of the ramp?

(a) Ramp A
(b) Ramp B
(c) Ramp C
(d) None of the above; the speed at the bottom is the same for each ramp.

$E_i = E_f$ so $\Delta E = 0$
$\Delta PE_{grav} + \Delta KE = 0$
Same ΔPE_{grav} in all cases so same ΔKE

13. Suppose that a system consists of only gravitational potential energy and kinetic energy. If there are no energy inputs and outputs, then if the potential energy *decreases*, the kinetic energy

(a) remains constant.
(b) decreases.
(c) increases.
(d) could either increase, decrease, or remain constant.

$E_i = E_f$
$E_i = PE_{grav,i} + KE_i$
bigger, smaller and vice versa

14. A 260-lb linebacker running at full speed collides with and tackles ~~and~~ 200-lb quarterback who is at rest. During the collision, the magnitude of the change in *momentum* of the linebacker is

$\Delta\vec{p}_{linebacker} = -\Delta\vec{p}_{QB}$

(a) greater than the magnitude of the change in momentum of the quarterback.
(b) less than the magnitude of the change in momentum of the quarterback.
(c) equal to the magnitude of the change in momentum of the quarterback.

15. A 260-lb linebacker running at full speed collides with and tackles ~~and~~ 200-lb quarterback who is at rest. During the collision, the magnitude of the change in *velocity* of the linebacker is

(a) greater than the magnitude of the change in velocity of the quarterback.
(b) less than the magnitude of the change in velocity of the quarterback.
(c) equal to the magnitude of the change in velocity of the quarterback.

$|\Delta\vec{p}_A| = |\Delta\vec{p}_B|$
$m_A|\Delta\vec{v}_A| = m_B|\Delta\vec{v}_B|$
bigger mass has smaller $|\Delta\vec{v}|$

16. Suppose that the linebacker in the previous question has a velocity 0.8 m/s in the +x direction, when he hits the quarterback who is at rest. What will be their x-velocity after the collision? Note: the linebacker "tackles" ~~and~~ the quarterback.)

(a) 0.45 m/s
(b) 1.0 m/s
(c) 0.62 m/s
(d) 1.4 m/s
(e) 0.35 m/s

$M_A v_{Aix} = (m_A + m_B) v_f$

$v_f = \frac{260}{(200+260)}(0.8) = 0.45 \frac{m}{s}$

17. You hang a 0.5-kg object from the end of the spring and let it hang in equilibrium. The spring stretches 0.25 m. What is the stiffness k of the spring?

(a) 4.9 N/m
(b) 39 N/m
(c) 15 N/m
(d) 20 N/m
(e) 10 N/m

$\Sigma F_y = 0$

$kx = mg \quad k = \frac{mg}{x} = 19.6 \frac{N}{m}$

18. A softball player is running with a speed of 0.7 m/s when she slides into home plate and comes to a stop. If her mass is 60 kg, what is her change in kinetic energy as a result of sliding?

(a) −21.0 J
(b) 21.0 J
(c) −42.0 J
(d) 42.0 J
(e) −14.7 J

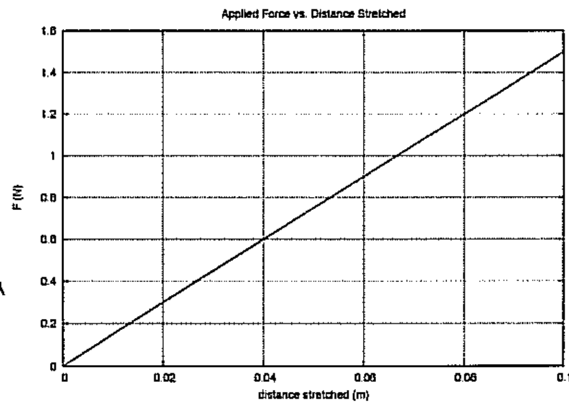
$\Delta KE = K_f - K_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = 0 - \frac{1}{2}(60)(0.7)^2 = -14.7 J$

19. While working out, you build certain muscle groups by holding each end of a very stiff spring (using handles attached to the spring) and stretching it. If the spring has a stiffness 100 N/m, and you stretch it 20 cm, what is the elastic potential energy of the spring?

(a) 4 J
(b) 10 J
(c) 100 J
(d) 20 J
(e) 2 J

$PE_{elas} = \frac{1}{2}kx^2 = \frac{1}{2}(100)(0.2)^2 = 2 J$

20. You stretch a spring and use a force sensor and motion detector to measure and graph the applied force vs. the distance stretched. The resulting graph is shown below.



What is the stiffness of the spring?

(a) 20 N/m
(b) 0.1 N/m
(c) 1.5 N/m
(d) 10 N/m
(e) 15 N/m

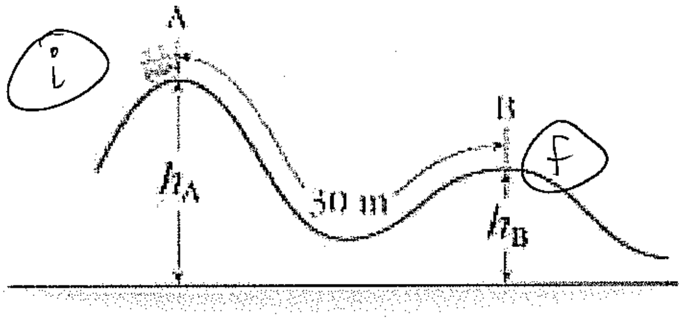
$F = kx$

k = slope of F vs. x graph

$\text{slope} = \frac{0.6 N}{0.04 m} = 15 \frac{N}{m}$

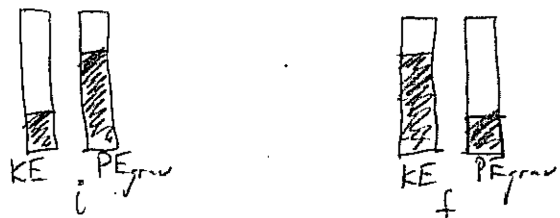
Section 2. Problem Solving

21. A kid's roller coaster at point A has a height of 16 m and a speed of 2.0 m/s. Its height as point B is 8.0 m. If full of kids, its total mass is 250 kg. **Define y=0 to be ground level.**



(a) Sketch a bar graph showing the initial kinetic and gravitational potential energy and the final kinetic and gravitational potential energy, like those drawn in class. Be sure that the total energy is constant.

(+5)



– sum should be equal to the height of the bar.

– KE increases, PE_{grav} decreases

– sum should be the same, $E_i = E_f$

(b) If friction is negligible, what will be its speed at point B?

$E_i = E_f$ if frictionless

(+5)

$M = 250$ kg

$y_i = 16$ m

$y_f = 8$ m

$v_i = 2\ \frac{m}{s}$

$V_f = ?$

$PE_i + KE_i = PE_f + KE_f$

$mgy_i + \frac{1}{2}mv_i^2 = mgy_f + \frac{1}{2}mv_f^2$ (+5)

$(250)(9.8)(16) + \frac{1}{2}(250)(2)^2 = (250)(9.8)(8) + \frac{1}{2}(250)v_f^2$

$39200\ J + 500\ J = 19600\ J + 125 v_f^2$ (+5)

$20100 = 125 v_f^2$

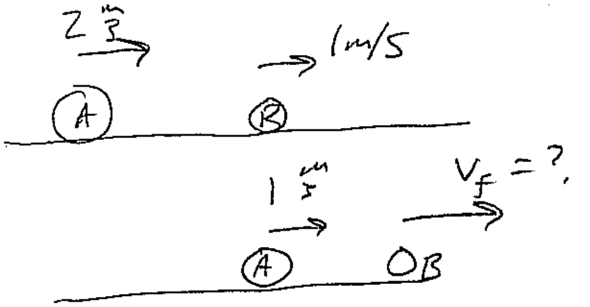
$v_f^2 = 160.8$

$v_f = \sqrt{160.8} = \boxed{12.7\ \frac{m}{s}}$ (+5)

(+20)

22. Pairs skaters perform an element where the male partner of mass 100 kg initially skating with a speed of 2 m/s in the +x direction pushes the female partner of mass 50 kg who is initially skating with a speed of 1 m/s in the +x direction. After pushing the female partner, the male partner has an x-velocity of +1.0 m/s. What is the final x-velocity of the female skater (i.e. her x-velocity after the push by her partner)? (Note: this can be considered a "collision" between the skaters.)

Initial:



final:

+5

$m_A = 100$ kg
$m_B = 50$ kg
$V_{Aix} = 2$ m/s
$V_{Bix} = 1$ m/s
$V_{Afx} = 1$ m/s
$V_{Bfx} = ?$

+5

+5 $P_{ix} = P_{fx}$ conservation of momentum

$$M_A V_{Aix} + m_B V_{Bix} = m_A V_{Afx} + m_B V_{Bfx}$$

$$100(2) + 50(1) = 100(1) + 50\, V_{Bfx}$$ +5

$$250 - 100 = 50\, V_{Bfx}$$

$$150 = 50\, V_{Bfx}$$

$$V_{Bfx} = \frac{150}{50} = 3 \frac{m}{s}$$ +5

+25