Physics 110 – Spring 2014
Hour Exam #1

Name:_______KEY______________________________

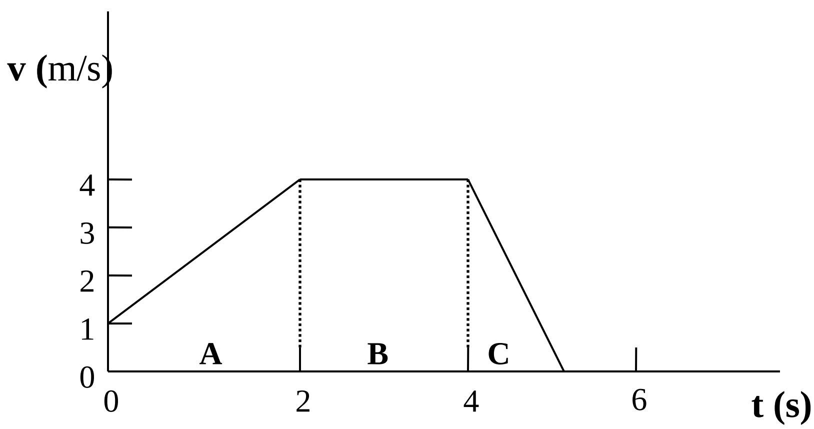
I affirm that I have carried out my academic endeavors with full academic honesty.

*Signed:*____

Short answers (2.5 pts each for a total of 25 pts): **Answer all questions with only one response in the margin.**

_____C______1. Which of the following is a true statement:
a. The mass of an object depends on the forces acting on it;
b. The weight of an object is constant no matter where on the Earth it is located;
c. The mass of an object is the same on the Earth as it would be on the Moon;
d. Mass and weight have the same units.

_____B______2. At a turning point in the motion of an object
a. The velocity can be positive or negative but the acceleration must be instantaneously zero;
b. the velocity must be instantaneously zero, but the acceleration can be positive or negative;
c. both the velocity and acceleration must be instantaneously zero;
d. the velocity and acceleration must have opposite signs (i.e. one positive and the other negative).



______D_____3. If the above graph is for a 4 kg object, the forces acting during each of these three intervals (A, B, C) are given (in Newtons) by
a. (6, 0, 16); b. (-6, 0, 16); c. (3/2, 0, -4); d. (6, 0, -16)

______B_____4. If the object described by the above graph starts at the origin at t = 0, where will it be at t = 4 s?
a. x = 11 m; b. x = 13 m; c. x = 8 m; d. x = 4 m.

______A_____5. A 10 N mass stretches a vertical spring by 10 cm. When set into oscillation, the time for the mass to travel from its highest to its lowest position is equal to (take $g = 10\ m/s^2$)
a. 0.31 s; b. 0.63 s; c. 0.99 s; d. 1.99 s.

_______B______6. A mass m attached to a horizontal spring with constant k is set in simple harmonic motion with amplitude A. At the point when the mass is moving to the right with its greatest speed, its acceleration is given by

a. $\frac{k}{m}A$; b. 0; c. $-\frac{k}{m}A$; d. $\sqrt{\frac{k}{m}}A$.

_______C______7. A ball of mass m is thrown upward with a speed v_o. The work done on the ball while in "free fall" in going from its initial height to returning to that same height is given by

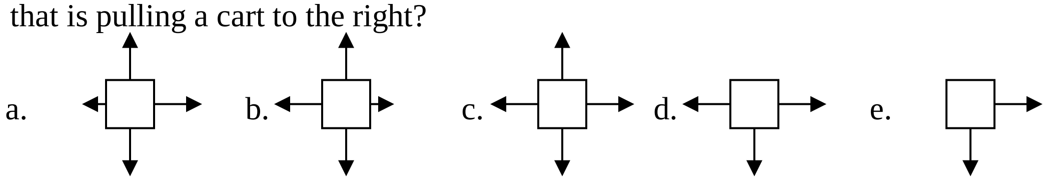
a) $\frac{1}{2} m v_o^2$ b) $2(\frac{1}{2} m v_o^2)$ c) 0 d) none of these

_______D______8. A heavy crate is pushed 4 m across the horizontal floor by a person exerting a 30 N force. The floor exerts a frictional force of 20 N. The net work done on the crate is

a) 120 J b) 200 J c) 0 J d) 40 J

_______A______9. A ladder is at rest leaning against a vertical wall. The reaction force to the normal force on the ladder at the wall is a) the normal force on the wall ; b) the frictional force on the ladder at the floor; c) the frictional force on the ladder at the wall; d) the frictional force on the wall at the ladder.

_______A_______10. Which of the following represents the correct free-body diagram for an accelerating horse that is pulling a cart to the right?



Problems: **<u>Answer all parts and show all work for full credit</u>.**

1. (24 pts) A 0.5 kg ball is thrown vertically upward at 8 m/s from the edge of a 10 m tall cliff. (Neglect air resistance.)
(10 pts) a) Find the maximum height the ball reaches above its starting height *and* the time it takes to reach that height.

Using $v^2 = v_o^2 + 2a\Delta x$ we have, with $v = 0, g = -9.8, \Delta x = \frac{v_o^2}{2g} = 3.27\ m$

Also, using $v = v_o + gt, with\ v = 0, g = -9.8, t = \frac{v_o}{g} = 0.82s$

(6 pts) b) Find the speed *and* acceleration of the ball just before it hits the ground, 10 m below its starting height.

Using $v^2 = v_o^2 + 2a\Delta x, with\ v_o = 8, a = 9.8, \Delta x = 10, we\ find\ v = \sqrt{v_o^2 + 2a\Delta x}$ = $\sqrt{8^2 + 2(9.8)(10)}$ = 16.1 m/s downward
Also, $a = 9.8\frac{m}{s^2}\ downward, throughout\ the\ motion$

(8 pts) c) What is the ball's average *speed* for the entire trip? What is its average *velocity* for the entire trip?

The average speed is the total distance traveled divided by the total time:

$$< speed > = \frac{(3.27+3.27+10)}{total\ time},$$

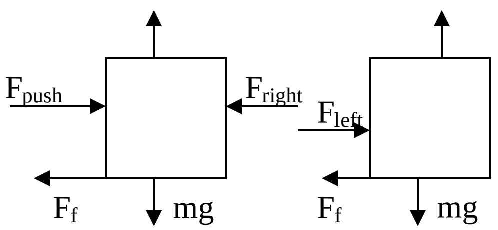
where the total time = 0.82 + 0.82 + T, with T = time on way down from top of cliff to ground. This time is found from, for example, $v = v_o + gT, with\ v = 16.1\frac{m}{s}\ down\ (part\ b), v_o = 8\frac{m}{s} down, and\ g = 9.8\ down\ --Thus\ T = \frac{v - v_o}{g} = \frac{16.1-8}{9.8} = 0.83\ s.$ We find that the average speed is then equal to $< speed > = \frac{(3.27+3.27+10)}{(0.82+0.82+0.83)} = 6.7\ m/s$

On the other hand the average velocity is the net displacement, 10 m, divided by the total time or $< velocity > = \frac{10}{(0.82+0.82+0.83)} = 4.05\frac{m}{s} downward$

2. (26 pts) Two identical crates, each of 5 kg mass, sit side-by-side, in contact with each other, on a horizontal surface.
(8 pts) a) If a constant 15 N force pushes the left crate to the right, and there is a frictional force on each crate equal to 5 N, find the acceleration of the crate on the right. (Hint: solve this by treating the two crates as one object)

Treat the two crates as one – the net horizontal force is +15 – 5 – 5 = 5 N since a 5 N friction force acts on each block. Then $F_{net} = ma$, with total mass 10 kg, gives that $a = 5/10 = 0.5\ m/s^2$

(10 pts) b) Draw a carefully labeled pair of free-body diagrams, one for each crate, for the above situation. Find the force that the left crate exerts on the crate on the right in part (a).



In the above free-body diagrams the pair of left-right forces are equal and opposite and represent the forces the crates exert on each other.

F = ma for the right block gives:

$F_{left} – F_f = ma = 5\ (0.5) = 2.5$ N so that F_{left}, which we are looking for, is given by $F_{left} = F_f + 2.5 = 5 + 2.5 = 7.5$ N

(8 pts) c) Suppose the crates start from rest and the 15 N force acts for 10 s and then “shuts off” (the friction forces continue to act). Find the speed of the right crate after a total of 15 s (that is, 5 s after the 15 N force ends). [Hint: you will need to consider two separate time intervals, since the acceleration will change without the 15 N force acting.]

For 0 – 10 s, we found the acceleration to be $0.5\ m/s^2$. Using this we find that after 10 seconds, the crates are going at $v = 0 + at = 5$ m/s. Then the pushing force shuts off and the remaining net force is -10 N (from the two friction forces) and so we can find the acceleration for the time interval 10 – 15 sec to be $-10 = (10)\ a$ or $a = -1\ m/s^2$. Then the final v after 15 s is given by
$v = 5 + (-1)\ (5\ s) = 0$ and so the crates have just stopped.

3. (25 pts) Water from a well is hoisted up in a pail attached to a vertical (light) rope going over a pulley. If the bucket of water has a mass of 10 kg answer the following parts of the problem.

a) (9 pts) If the bucket is raised at a constant speed of 2.0 m/s,

i) what is the net work done on the bucket in raising it 20 m?

$W_{net} = \Delta(KE)$; but speed is constant and so KE = constant, so $W_{net} = 0$.

ii) what is the work done by gravity in raising the bucket the 20 m?

$W_{gravity} = (-mg)(20\text{ m}) = -1960\text{ J}$

iii) what is the total mechanical energy of the bucket after raising it by **10 m** with respect to the water level?

$E = PE + KE = (10)(9.8)(10) + \frac{1}{2}(10)(2)^2 = 1000\text{ J}$

b) (6 pts) What force must be exerted on the bucket by the rope?

$F_{rope} = mg = 98\text{ N}$ so that $F_{net} = 0$ since v = constant (a = 0)

c) (10 pts) If, while the bucket is being pulled upward at the top of its motion, the rope is released, with what velocity will the bucket hit the water, 20 m below? *Solve this problem using energy ideas.*

$E_{top} = \frac{1}{2} mv^2 + mgH = \frac{1}{2}(10)(2)^2 + (10)(9.8)(20) = 1980\text{ J}$

While

$E_{bottom} = \frac{1}{2}(10)v^2 + 0$; so conservation of mechanical energy says

$1980 = \frac{1}{2} 10v^2$ resulting in $v = 19.9\text{ m/s}$