Physics 6A

Introduction to Physics

Midterm Exam 1

October 23, 1998

- Closed book. No notes.
- Calculators with cleared memory are okay.
- Show your work on all calculations.

You should have 3 sheets and 6 pages, with 16 problems.
All numerical constants should be assumed to be accurate to two significant figures.

Equations for motion in one dimension, \( x \), with constant acceleration:
\[
x = x_0 + v_0 t + \frac{1}{2} a t^2 \quad x = x_0 + \frac{1}{2} (v_0 + v) \cdot t
\]
\[
v = v_0 + a t \quad v^2 = v_0^2 + 2a(x - x_0)
\]

Newton's second law: 
\[
\vec{a} = \frac{1}{m} \cdot \vec{F}_{net}
\]

Magnitude of the acceleration of gravity at the surface of the earth: 9.8 m/s²

1) (3 pts) Two metal balls are the same size but one weighs twice as much as the other. They roll off of a horizontal table at the same speed. In this situation,
   a) the heavier ball hits the floor at about half the horizontal distance from the base of the table than does the heavier ball.
   b) the lighter ball hits the floor at about half the horizontal distance from the base of the table than does the heavier ball.
   c) both balls hit the floor at approximately the same horizontal distance from the table.
   d) the heavier ball hits the floor much closer to the base of the table than the lighter ball, but not necessarily at half the horizontal distance.

2) (3 pts) Consider the forces on a ball shot at high speed through a curved frictionless channel as illustrated below, where the channel is fixed to a table top and viewed from above. Which of the following forces are acting on the ball at point \( Q \)? (Ignore air resistance.)

A. A force in the direction of motion.  
B. A force pointing from \( Q \) to \( O \) exerted by the channel on the ball.  
C. A force pointing from \( O \) to \( Q \).  
D. A downward force from gravity.

a) D only.  
b) A and D.  
c) B and D.  
d) C and D.
3) (3 pts) Which of the following paths below would the ball most closely follow after it exits the channel at R and moves across the frictionless tabletop?

![Path Diagram]

1st Law

4) (8 pts) Consider the following graph of acceleration as a function of time. Select the best corresponding graphs of velocity versus time and position versus time that together with the acceleration graph make a consistent set. In each of the v, t and x, t graphs the origin (0,0) is at the lower left hand corner and the time extends over the same range as in the acceleration graph.

![Acceleration Graph]

...
5) (3 pts) A large truck breaks down on the road and receives a push back into town by a small compact car. While the car, still pushing the truck, is speeding up to get up to cruising speed, 
   a) the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car. 
   b) the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car. 
   c) the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car. 
   d) the car pushes against the truck, but the truck, not having a functional engine, does not push against the car.

6) (3 pts) A bowling ball accidently falls out of the cargo hold of an airliner traveling at constant velocity \( \vec{v} \) in level flight. Which of the trajectories drawn below best represents the path that the ball would take as it falls to the ground, as seen by a stationary observer on the ground? (Note that the airplane is drawn at the position at which the bowling ball falls out. The airplane continues traveling to the right.)

7) (3 pts) A package of supplies is dropped from a plane, and one second later a second package is dropped. If air resistance is negligible, then 
   a) the vertical separation between the packages will steadily decrease with time. 
   b) the packages will fall with a constant vertical separation. 
   c) the vertical separation between the packages will steadily increase with time. 
   d) the vertical separation between the packages will decrease with time only if the second package is more massive than the first.

8) (3 pts) If you wish to cross a flowing river in a motorboat, your time of crossing will be least if you keep the bow of the boat pointed 
   a) slightly downstream. 
   b) slightly upstream. 
   c) directly toward the opposite bank. 
   d) slightly upstream half of the way and slightly downstream the remaining half.

9) (3 pts) An object is thrown straight up. At the top of its path the net force acting on it is 
   a) greater than zero but less than its weight. 
   b) equal to its weight. 
   c) greater than its weight. 
   d) instantaneously equal to zero.

7) The 1st package has a speed \( v_0 = \frac{1}{2} gt^2 \) when the 2nd is dropped, where \( t_0 \) is the time between dropping 1 and 2. So the spacing will increase as \( v_0 t \) after the 2nd is dropped.
10) (4 pts) Two projectiles are shot upward with equal speed, but with different initial angles with respect to the level ground. The projectile that stays aloft the longest is the one that goes the highest.

(a) TRUE
(b) FALSE (If false, you must modify the statement to make it true.)

11) (4 pts) You are on the moon and throw a moon-rock to your fellow astronaut. At its highest point above the surface of the moon, the velocity of the rock is zero, and the acceleration is zero.

vertical \hspace{1cm} \text{downward}

(a) TRUE
(b) FALSE (If false, you must modify the statement to make it true.)

12) (4 pts) For a horse standing at rest, the weight of the horse is equal and opposite to the normal force exerted upward on the horse by the ground, because these two forces form an interaction pair that are always equal and opposite according to Newton’s third law. Because there is no vertical acceleration.

(a) TRUE
(b) FALSE (If false, you must modify the statement to make it true.)

13) (6 pts) Can the magnitude of the acceleration of an object be decreasing at the same time that the speed is increasing? If not, then explain why not. If yes, then give an example.

Yes, an object falling through a fluid, before the terminal velocity is reached.

Or, an object going down this hill

[Signature]
A car starts from rest and accelerates to the edge of a precipice 20 m away with a constant acceleration of 10 m/s² and goes over. Given that the ground is 40 m below the edge and that air resistance is negligible,

a) how long does the car remain in the air?

\[ y - y_0 = v_{y0} t - \frac{1}{2} g t^2 = -\frac{1}{2} g t^2 \]
\[ t = \sqrt{-\frac{2(y - y_0)}{g}} = \sqrt{-\frac{2(0 - 40)}{9.8}} = 2.86 \text{s} \]

b) Just before going over
\[ v_{x}^2 = 2a(x - x_0) \]
\[ v_x = \sqrt{2 \cdot 10 \cdot 0.20} = 20.0 \text{ m/s} \]
Range beyond cliff \( \Delta x = v_x t = 20.0 \cdot 2.86 = 57.2 \text{ m} \)

c) \( v_y = v_{y0} - gt = 0 - 9.8 \cdot 2.86 = 28.0 \text{ m/s} \)
\[ v = \sqrt{v_x^2 + v_y^2} = \sqrt{20^2 + 28^2} = 34.4 \text{ m/s} \]
15) (14 pts) A 50 kg woman is standing on an accurate bathroom weight scale in an elevator that is accelerating upward at 2.8 m/s². What is the reading on the scale, in kilograms?

\[
\begin{align*}
\text{The scale measures } F_N &= m\dddot{a} \\
F_N &= mg = ma \\
F_N &= m(a + g) = 50 \cdot (2.8 + 9.8) \\
&= 630 \text{ N} \\
\text{Scale reads } \frac{F_N}{g} &= \frac{630}{9.8} = 64.3 \text{ kg}
\end{align*}
\]

16) (12 pts) Two donkeys are pulling a barge along a level canal, with one donkey on each side of the canal.

The donkeys share the load equally, and each rope between donkey and barge makes an angle of 37° with respect to the direction of motion of the barge. The mass of the barge is 750 kg, and there is a constant drag force opposing the motion of the barge of 500 N. Assuming that barge moves with a constant velocity, what is the tension in each of the ropes?

\[
\begin{align*}
2\text{nd law in x direction: } &\quad 2T \cos 37° - 500 N = ma = 0 \\
&\quad T = \frac{500}{2 \cos 37°} = 313 N
\end{align*}
\]