Physics 151 Midterm 1

The following information pertains to questions 1 and 2: A stray cat walks 4.0 m due north then 4.0 m due west then 1.0 m due south.

1. What is the magnitude of the cat's total displacement?
   a. 1.0 m   b. 2.0 m   c. 3.0 m   d. 4.0 m   e. 5.0 m   f. 7.0 m

2. What is the direction of the cat's total displacement?
   a. 37° north of due west   b. 37° south of due west
   c. 53° north of due west   d. 53° south of due west
   e. 45° north of due west   f. 45° south of due west

\[ \theta = \tan^{-1}\left(\frac{3}{4}\right) = 36.9° \]

3. A world-class sprinter runs a 100 m race in 10.0 seconds. Which of the following statements concerning the sprinter's motion during the race is not necessarily true? (The 100 m dash starts with the runners at rest and is run on a straight track)
   a. The sprinter's average speed for the whole race is 10.0 m/s.
   b. At some point during the race the sprinter has an instantaneous speed less than 10.0 m/s.
   c. At some point during the race the sprinter has an instantaneous speed equal to 10.0 m/s.
   d. At some point during the race the sprinter has an instantaneous speed greater than 10.0 m/s.
   e. The sprinter's acceleration is constant throughout the race.
   f. The sprinter's velocity points in the same direction throughout the race.

4. A car is moving at a constant velocity. Which of the following statements is not necessarily true?
   a. The car is neither speeding up nor slowing down
   b. The car is traveling on a straight portion of road
   c. The acceleration of the car is zero.
   d. The car is traveling on a flat (horizontal) portion of road
   e. The net force acting on the car is zero.

5. If an object is speeding up, which of the following statements must be true?
   a. The instantaneous velocity and acceleration of the car are in the same direction
   b. The instantaneous velocity and acceleration of the car are in opposite directions.
   c. The car has a positive acceleration.
   d. The car has a negative acceleration.
The following graphs pertain to questions 6-12. For these questions, more than one answer may apply.

The four graphs above show an object's position as a function of time. Assume we are using a coordinate system where the positive x-direction points to the right.

6. Which of the above graphs represents an object that is speeding up? (circle the appropriate roman numeral(s))

I  II  III  IV  None

7. Which of the above graphs represents a particle that is slowing down? (circle the appropriate roman numeral(s))

I  II  III  IV  None

8. Which of the above graphs represents a particle whose acceleration is zero? (circle the appropriate roman numeral(s))

I  II  III  IV  None

9. Which of the above graphs represents a particle whose acceleration points in the negative x direction? (circle the appropriate roman numeral(s))

I  II  III  IV  None

10. Which of the above graphs represents a particle whose initial position is at the origin? (circle the appropriate roman numeral(s))

I  II  III  IV  None

11. Which of the above graphs represents a particle whose velocity is constant? (circle the appropriate roman numeral(s))

I  II  III  IV  None

12. Which of the following graphs represents a particle that is moving to the left? (circle the appropriate roman numeral(s))

I  II  III  IV  None
13. A ball is thrown directly upwards with a velocity of +20 m/s. Neglecting air resistance, at the end of 4 s its speed will be closest to (Hint: Let g be 10 m/s² instead of 9.8 m/s²)

a. 50 m/s  b. 40 m/s  c. 30 m/s  d. 20 m/s  e. 10 m/s

14. A bullet is dropped into a river from a very high bridge. At the same instant, another bullet is fired from a gun straight down towards the water. If air resistance is negligible, the acceleration of the bullets just before they strike the water

a. is greater for the dropped bullet.
b. is greater for the fired bullet.
c. is the same for both bullets.
d. depends on how high they started.

equal \( g = 9.8 \frac{m}{s^2} \) down for both

15. A car is driving toward a building at 10 mph. On the roof of the car, an insect is scurrying away from the building at 15 mph relative to the car’s roof. To a person sitting in the building, the insect’s velocity is

a. 25 mph away from the building
b. 25 mph toward the building
b. 5 mph away from the building
d. 5 mph toward the building

16. A stone is thrown horizontally with a speed of 15 m/s from the top of a vertical cliff at the edge of a lake. If the stone hits the water 2.0 s later, the height of the cliff is closest to (Hint: Let g be 10 m/s² instead of 9.8 m/s²)

a. 10 m  b. 20 m  c. 30 m  d. 40 m  e. 50 m

17. A stone is thrown with an initial speed of 20 m/s at an angle of 60° above the horizontal from the edge of a vertical cliff. If the stone strikes the water 2.0 s later, how far from the base of the cliff does the rock land? (that is how far does it travel in the horizontal direction)

a. 20 m  b. 30 m  c. 40 m  d. 50 m  e. 60 m

18. A man is pulling a refrigerator with a force of 180 N at an angle of 30 degrees above the horizontal as shown. If the refrigerator moves at a constant velocity of 2.00 m/s to the right, what is the force of friction that acts on the refrigerator?

a. 220 N  b. 180 N  c. 191 N  d. 156 N
e. 110 N  f. 90.0 N
g. It is impossible to tell since we are not given the coefficient of kinetic friction

\[ \sum F_x = ma_x \]
\[ + F_{p_y} - F_{f_x} = 0 \]
\[ F_{f_x} = F_{p_y} = 180N \cos 30° = 156N \]
19. A 10.0 kg object is sitting on a scale and has a rope attached to it as shown. If the scale reads 28.0 N, what is the tension in the rope?

\[ F_T + F_s = m g - F_s \]
\[ F_T = m g - F_s \]
\[ 98 \text{ N} - 28 \text{ N} = 70 \text{ N} \]

(a) 60.0 N  (b) 70.0 N  (c) 98.0 N  (d) 126 N  (e) 136 N

20. A 2.0 kg object has two forces acting on it. One force is 25.0 N due east. The particle starts at rest and is acted upon the two forces for 4.0 seconds. After the 4.0 seconds, the object is located 40.0 m to the west of where it started. What is the magnitude and direction of the other force that acts on the object?

(a) 5 N to the west  (b) 10 N to the west  (c) 15 N to the west  (d) 25 N to the west

\[ x = x_0 + v_0 t + \frac{1}{2} a_x t^2 \]
\[ a_x = \frac{dx}{dt^2} \]
\[ x = \frac{2 \cdot 40 \text{ m}}{(4 \text{ s})^2} = -5 \frac{\text{m}}{\text{s}}^2 \]
\[ F_{N1} = m \ddot{a} = 2 \text{ kg} (-5 \frac{\text{m}}{\text{s}}^2) = -10 \text{ N} + \frac{5}{2} \text{ N} \]

\[ \Rightarrow \text{ other force is 15N} \]
\[ \Rightarrow \text{ other force is 35N} \]
Dee to its smaller size, the fictitious planet Henway has an acceleration of gravity equal to 6.0 m/s$^2$ as compared to the value of 9.8 m/s$^2$ here on Earth. On the planet Henway, a ball is kicked such that its initial horizontal component of velocity is 18 m/s and its initial vertical component of velocity is 24 m/s.

a. Fill in the following table that gives the balls vertical component of velocity for the first five seconds. (Hint, you should be able to do this in your head) [5 points]

<table>
<thead>
<tr>
<th>t (sec)</th>
<th>v (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>+24</td>
</tr>
<tr>
<td>1</td>
<td>+18</td>
</tr>
<tr>
<td>2</td>
<td>+12</td>
</tr>
<tr>
<td>3</td>
<td>+6</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>-6</td>
</tr>
</tbody>
</table>

b. What is the magnitude and direction of the balls initial velocity? [5 points]

\[ V_0 = \sqrt{(18 \text{ m/s})^2 + (24 \text{ m/s})^2} = 30 \text{ m/s} \]

(c. What is the magnitude and direction of the balls velocity 2.0 s after it is kicked? [5 points]

\[ V_x = \text{constant (} a_x = 0) \]
\[ V = \sqrt{(18 \text{ m/s})^2 + (12 \text{ m/s})^2} = 21.6 \text{ m/s} \]
\[ \theta = \tan^{-1} \left( \frac{12}{18} \right) = 33.7 \degree \]
\[ V_y = 12 \text{ m/s} \]
\[ \text{(see part a)} \]

(d. At what times, after it is kicked, is the ball 5.0 m above the ground? [5 points]

\[ \text{find } t \text{ when } y = 5 \text{ m} \]
\[ y = y_o + V_{yo}t + \frac{1}{2} a_y t^2 \]

Solve quadratic
\[ -3t^2 + 24t - 5 = 0 \]
\[ t = \frac{-24 \pm \sqrt{24^2 - 4(-3)(-5)}}{2(-3)} = \text{als}, 7.8 \text{ s} \]
Due to its smaller size, the fictitious planet Henway has an acceleration of gravity equal to 6.0 m/s² as compared to the value of 9.8 m/s² here on Earth. Our hero Fred is standing on a scale (His scale reads in Newtons) in an elevator as shown. Fred has a mass of 50 kg

a. If the elevator is moving at a constant velocity of 5.0 m/s upwards, what does the scale read?[5 points]

\[ \sum F_y = m a_y \]
\[ F_y - m g = 0 \]
\[ F_y = m g = 50 \times 5 \cdot 6 \frac{m}{s^2} = 300 \text{ N} \]

b. If the scale reads 600 N, what is the magnitude and direction of the elevator's acceleration?[5 points]

\[ \sum F_y = m a_y \]
\[ F_y - m g = m a_y \]
\[ a_y = \frac{F_y - m g}{m} = \frac{600 \text{ N} - 300 \text{ N}}{50 \times 5} \]
\[ a_y = + \frac{6 m}{s^2} \text{ upwards} \]

(c. If the scale reads 100 N and the elevator has a constant acceleration and an initial velocity of 4.0 m/s, where will the elevator be 5.0 seconds later relative to its initial position?[10 points]

\[ a_y = \frac{F_y - m g}{m} = \frac{100 \text{ N} - 300 \text{ N}}{50 \times 5} \]
\[ a_y = - \frac{4 m}{s^2} \]

\[ y = y_0 + v_{y0} t + \frac{1}{2} a_y t^2 \]
\[ y = 4 \frac{m}{s} \cdot 5 s + \frac{1}{2} \left( -\frac{4 m}{s^2} \right) (5 s)^2 \]
\[ y = 20 m - 50 m = -30 m \text{ i.e. 30 m below where it was} \]