Physics 123H - Practice Midterm I

1. A particle moves 30cm west and then changes direction, moving $50\sqrt{2}$ cm north-east. The unit vector $\hat{i}$ points east, while the unit vector $\hat{j}$ points north. What is the displacement vector of the particle measured in meters?

(a) $0.5\hat{j}$
(b) $0.3\hat{i}$
(c) $-0.3\hat{i} + 0.5\hat{j}$
(d) $0.2\hat{i} + 0.5\hat{j}$
(e) $-0.2\hat{i} + 0.5\hat{j}$

2. A car moves along the $x$-axis with constant acceleration $2m/s^2$ for 10 minutes and then slows down with constant acceleration $-1m/s^2$ for 6 minutes. What is the average acceleration of the car during this time interval measured in $m/s^2$?

blue (a) 0.875
(b) 1
(c) 1.125
(d) 0.5
(e) cannot be determined; need to know the initial velocity of the car.

3. A particle $A$ moves with constant velocity $v_{Ax} = 20 \text{ m/s}$ along the $x$-axis. At time $t = 0$ a second particle $B$ starts moving from rest in the $(x, y)$-plane with constant acceleration

\[ \vec{a}_B = 12\hat{i} - 7\hat{j} \]

measured in $m/s^2$. What is the relative velocity of particle $B$ with respect to particle $A$ at time $t = 2 \text{ s}$?

(a) $-7\hat{j}$
(b) $4\hat{i} - 14\hat{j}$
4. A car moving along the $x$ axis with velocity $v_{0x} = 20 \text{ m/s}$ starts slowing down when it crosses the origin with constant acceleration of magnitude $4 \text{ m/s}^2$. What is the velocity of the car at $x = 32 \text{ m}$.

(a) $6 \text{ m/s}$
(b) $8 \text{ m/s}$
(c) $10 \text{ m/s}$
(d) $14 \text{ m/s}$
(e) $12 \text{ m/s}$

5. A particle moving with constant acceleration $a_x = -2 \text{ m/s}^2$ along the $x$-axis is at the origin at time $t = 0$. The initial velocity of the particle is $v_{0x} = 4 \text{ m/s}$. How long will it take for the particle to reach $x = 4 \text{ m}$?

(a) $2 \text{ s}$
(b) $5 \text{ s}$
(c) $8 \text{ s}$
(d) $3 \text{ s}$
(e) it will never reach $x = 4 \text{ m}$.

6. Particle $A$ moves with constant velocity $\vec{v}_{A,x} = 160 \text{ m/s}$ along the $x$ axis and it crosses the origin at time $t = 0$. At the same time particle $B$ starts moving from $x_{0B} = 640$ with constant acceleration $a_{B,x} = -20 \text{ m/s}^2$ and zero initial velocity. How long will it take for the two particles to collide?

(a) $12 \text{ s}$
(b) $5 \text{ s}$
7. A skydiver jumps out of an airplane moving horizontally with constant acceleration \( a = 5 \text{ m/s}^2 \) along the \( x \)-axis. What is the relative acceleration of the skydiver with respect to the plane (measured in \( m/s^2 \)) during free fall? The \( y \) axis is vertical and points upward.

\( (a) \ 5\hat{i} \)
\( (b) \ -9.8\hat{j} \)
\( (c) \ 5\hat{i} + 9.8\hat{j} \)
\( (d) \ -5\hat{i} - 9.8\hat{j} \)
\( (e) \text{ cannot be determined from the data} \)

8. A particle moves on a curved path on in the \((x, y)\) plane. The velocity vector of the particle at time \( t_1 = 2 \text{s} \) is
\[
\vec{v}_1 = -13\hat{i} + 8\hat{j}
\]
and the velocity vector at time \( t_2 = 6 \text{ s} \) is
\[
\vec{v}_2 = 11\hat{i} - 4\hat{j}
\]
All components are measured in \( m/s \). What is the magnitude of the average acceleration of the particle in this time interval, measured in \( m/s^2 \)?

\( (a) \ 2\sqrt{5} \)
\( (b) \ \sqrt{7} \)
\( (c) \ 3\sqrt{5} \)
\( (d) \ 6\sqrt{3} \)
\( (e) \ 4\sqrt{7} \)
9. At $t = 0$ two particles A and B start moving simultaneously in the $(x, y)$ plane. The initial velocity vectors of the two particles at $t = 0$ are

$$\vec{v}_0A = \hat{i} + \hat{j}, \quad \vec{v}_0B = -\hat{i}. $$

The particles move with constant acceleration vectors

$$\vec{a}_A = 2\hat{i}, \quad \vec{a}_B = -\hat{j}. $$

What is the relative velocity $\vec{v}_{BA}$ of particle B with respect to A at time $t = 1s$?

(a) $\vec{v}_{BA} = -\hat{i} + 2\hat{j}$  
(b) $\vec{v}_{BA} = 2\hat{i} - \hat{j}$  
(c) $\vec{v}_{BA} = -4\hat{i} - 2\hat{j}$  
(d) $\vec{v}_{BA} = 0$  
(e) $\vec{v}_{BA} = -\hat{j}$.

10. At $t = 0$ a ball A is shot from the origin of a vertical $(x, y)$ plane with velocity vector

$$\vec{v}_0A = v_0\frac{(\hat{i} + \hat{j})}{\sqrt{2}},$$

where $v_0 > 0$. At the same time a second ball B is dropped with zero initial velocity from the point

$$\vec{r}_0B = 20(\hat{i} + \hat{j}).$$

Suppose ball A collides with B exactly at the same moment the latter hits the ground. What is $v_0$? Air resistance is negligible.

(a) $v_0 = 15$ m/s  
(b) $v_0 = 7$ m/s  
(c) $v_0 = 16$ m/s  
(d) $v_0 = 14$ m/s  
(e) $v_0 = 10$ m/s
11. An elevator descends with constant acceleration $\vec{a}_{\text{elevator}} = -(6.8 \text{ m/s}^2) \hat{j}$ relative to the Earth’s reference system, which is assumed inertial. A physicist inside the elevator drops a ball with zero initial velocity from height $h = 1.5 \text{ m}$ above the floor. How long will it take for the ball to hit the floor? The magnitude of the free fall acceleration is $9.8 \text{ m/s}^2$.

(a) 2 s  
(b) 3 s  
(c) 6 s  
(d) 1 s  
(e) 5 s

12. A river is 50 meters wide flows with constant speed $0.6 \text{ m/s}$. A swimmer crossing the river swims with constant relative velocity of magnitude $2 \text{ m/s}$ directed straight across the river with respect to the water. What is the total displacement of the swimmer along the $x$ axis?

(a) 10 m  
(b) 5 m  
(c) 12 m  
(d) 0 m  
(e) 15 m

13. A ball falls from height $h = 2$ in uniform gravitational field such that the total falling time is $T$. How high above the floor is the ball at time $t = T/2$.

(a) 1.5 m  
(b) 1 m  
(c) 0.5 m  
(d) 1.2 m
(e) 0.7 m

14. A bus moves horizontally with constant acceleration of magnitude $g/5$. Inside the bus a ball falls straight down from a height $h$ above the floor with zero initial velocity relative to the bus. Let $d$ be the total horizontal displacement of the ball during the fall. Then the ratio $d/h$ is

(a) 1
(b) 1/5
(c) 1/4
(d) 5
(e) 2/5

15. A projectile is launched from the origin in uniform gravitational field with velocity vector $v = 4\hat{i} + 5\hat{j}$ (measured in m/s). What is the ratio $x/y$ at time $t = 1$ after the launch?

(a) 0.1
(b) 30
(c) 20
(d) 0.5
(e) 40