Kuwait University　　Physics Department

Physics 101

Spring Semester

First Midterm Exam

Saturday, March 9, 2024

9:00 AM – 10:30 AM

Student's Name: ………………………………. Serial Number: ……………

Student's Number: …………………………………Section: ……………………

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Al Jassar, Al kurtas, Al Qattan, Al Refai, Al Smadi, Askar, Demir, Salameh

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	LP1	LP2	Q1	Q2	Q3	Q4	Total
Pts	2	2	2	2	2	3	3	1	1	1	1	20

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 20 points as arranged in the above table.
3. **Give your final answer in the correct units.**
4. Assume g = 10 m/s^2.
5. Mobiles are **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Short Problems (2 points each)

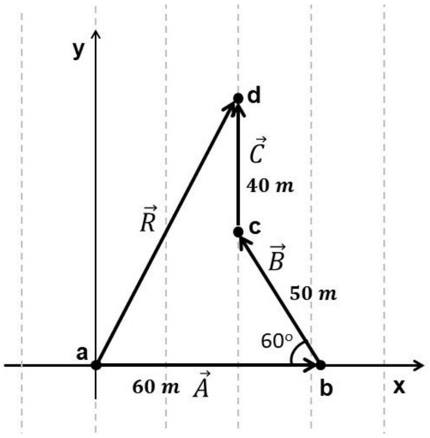
SP1. A man made three displacements: from **a to b**, then from **b to c**, and finally from **c to d,** as shown in the figure. **Find the resultant displacement vector $\vec{R}$ in unit vector notation.**

$\vec{A} = +60\ \hat{\imath}\ m$

$\vec{B} = -50\cos(60^o)\ \hat{\imath} + 50\sin(60^o)\hat{\jmath} = (-25\hat{\imath} + 43.3\hat{\jmath})\ m$

$\vec{C} = +40\ \hat{\jmath}\ m$

$\vec{R} = \vec{A} + \vec{B} + \vec{C} = (35\hat{\imath} + 83.3\hat{\jmath})\ m$



SP2. A particle moves in the xy-plane. Its position vector is given by $\vec{r}(t) = (3t - 2t^3)\hat{\imath} + (4t + t^3)\hat{\jmath}$, where $\boldsymbol{r}$ is in meters and $\boldsymbol{t}$ is in seconds. Find the **<u>magnitude</u> of the particle's acceleration at $\boldsymbol{t = 1s}$**.

$\vec{v}(t) = [\left(3 - 6t^2\right)\hat{\imath} + \left(4 + 3t^2\right)\hat{\jmath}]\quad m/s$

$\vec{a}(t) = (-12t\ \hat{\imath} + 6t\ \hat{\jmath})\ m/s^2$

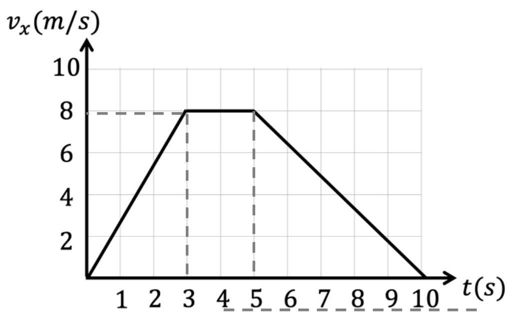
$\vec{a}(1s) = (-12\ \hat{\imath} + 6\ \hat{\jmath})\ m/s^2$

$|\vec{a}(1s)| = \sqrt{(12)^2 + (6)^2} = 13.4\ m/s^2$

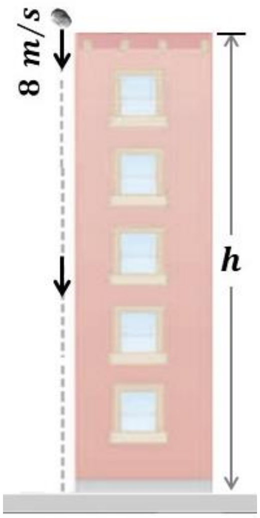
SP3. The velocity-time graph for a runner moving in a straight line is shown. **Find the average speed of the runner in the time interval from $\boldsymbol{t = 0\ s}$ to $\boldsymbol{t = 10\ s}$.**

$d = area = \frac{1}{2}(3)(8) + (2)(8) + \frac{1}{2}(5)(8) = 48\ m$

$v_{av} = \frac{d}{t} = \frac{48}{10} = 4.8\ m/s$



SP4. A stone is thrown **straight <u>down</u>** from a building of height h with an initial speed of $8\ m/s$, as shown. It takes $0.75\ s$ for the stone to hit the ground. **Find the height of the building.**

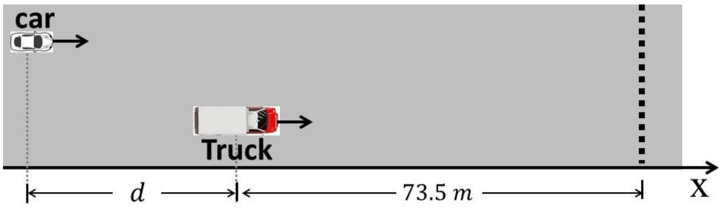


$$\Delta y = v_{y_i} t - \frac{1}{2} g t^2$$

$$-h = (-8)(0.75) - \frac{1}{2}(10)(0.75)^2$$

$$h = 8.8\ m$$

SP5. A car and a truck start **<u>from rest</u> at the same instant**, with the car initially at distance $\boldsymbol{d}$ **<u>behind</u>** the truck, as shown. The truck has a constant acceleration of $3\ m/s^2$, and the car has an acceleration of $4\ m/s^2$. The car overtakes the truck **after the <u>truck</u> has moved** $73.5\ m$. **Find the initial distance ($\boldsymbol{d}$) between the truck and the car.**



For the truck

$$\Delta x = v_{x_i} t + \frac{1}{2} a_x t^2$$

$$73.5 = 0 + \frac{1}{2}(3)t^2 \Rightarrow t = 7\ s$$

For the car

$$\Delta x = v_{x_i} t + \frac{1}{2} a_x t^2$$

$$d + 73.5 = 0 + \frac{1}{2}(4)7^2 \Rightarrow d = 24.5\ m$$

Part II: Long Problems (3 points each)

LP1: If $\vec{A} = 2\hat{\imath} + 3\hat{\jmath} - 2\hat{k}$ and $\vec{B} = \hat{\imath} - 2\hat{\jmath} + 3\hat{k}$.

a) Find $\vec{A} \times \vec{B}$

$$\vec{C} = \vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 2 & 3 & -2 \\ 1 & -2 & 3 \end{vmatrix}$$

$$= 5i - 8\hat{\jmath} - 7\hat{k}$$

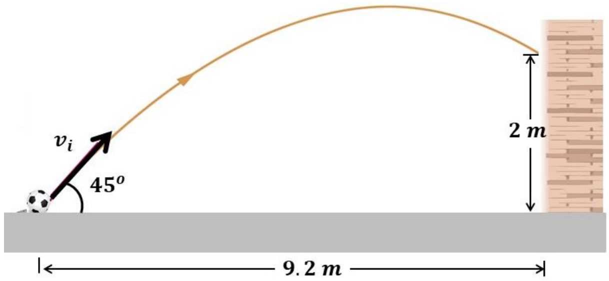
b) Find $\vec{A} \cdot \vec{B}$

$$\vec{A} \cdot \vec{B} = (2)(1) + (3)(-2) + (-2)(3) = -10$$

c) Find the angle between $\vec{A}$ and the positive z-axis.

$$\gamma = \cos^{-1}\left(\frac{A_z}{|\vec{A}|}\right) = \cos^{-1}\left(\frac{-2}{\sqrt{17}}\right) = 119^o$$

LP2: A ball is shot from the ground at an angle of 45° above the horizontal toward a wall, as shown. The ball hits the wall at a point 2 m above the ground level. **Ignore air resistance.**



a) How much time does it take for the ball to reach the wall?

$$v_{x_i} = v_i \cos 45° \text{ , } v_{y_i} = v_i \sin 45° \Rightarrow v_{x_i} = v_{y_i}$$

$$\Delta x = v_{x_i} t \quad \Rightarrow \ t = \frac{\Delta x}{v_{x_i}} = \frac{9.2}{v_{x_i}} = \frac{9.2}{v_{y_i}}$$

$$\Delta y = v_{y_i} t - \frac{1}{2} g t^2$$

$$2 = v_{y_i} (\frac{9.2}{v_{y_i}}) - \frac{1}{2}(10)t^2$$

$$\Rightarrow t = 1.2\ s$$

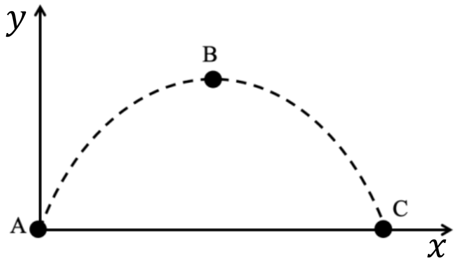
b) Find the initial speed of the ball.

$$\Delta x = v_{x_i} t \Rightarrow v_{x_i} = \frac{\Delta x}{t} = \frac{9.2}{1.2} = 7.67\ m/s$$

$$v_{x_i} = v_i \cos 45° \Rightarrow v_i = \frac{v_{x_i}}{\cos 45°} = \frac{7.67}{\cos 45°} = 10.8\ m/s$$

Part III: Questions (Choose the correct answer, one point each)

Q1. As a projectile moves along its trajectory. At which point do the velocity and acceleration vectors become **perpendicular** to each other?

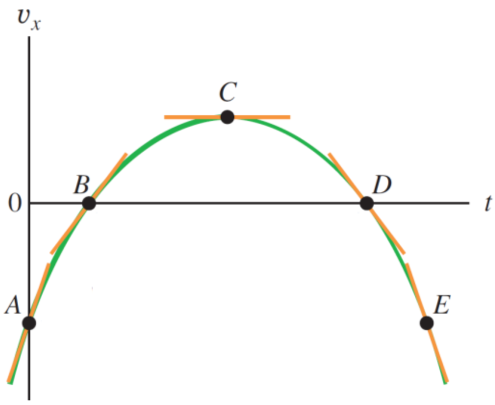


* A
* B
* C
* They are always perpendicular

Q2. If $\vec{A} = -5\vec{B}$ and $\vec{C} = \vec{A} \times \vec{B}$, then

* $\vec{C} = -6\vec{B}$
* $|\vec{C}| = |\vec{A}||\vec{B}|$
* $\vec{C} = +5\vec{B}$
* $\vec{C} = 0$

Q3. The velocity (v_x) versus time (t) graph for a particle moving along the x-axis is shown in the figure. The velocity and acceleration of the particle at point A, respectively are:



* $-, +$
* $+, -$
* $-, -$
* $+, +$

Q4. Which of the following statements **is always true?**

* the magnitude of the instantaneous velocity is always greater than the magnitude of the average velocity.
* the average velocity is always greater than the average speed.
* the average speed can never be negative.
* the average velocity can never be negative.