Kuwait University **Physics Department**

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Spring Semester
First Midterm Exam
Sunday, March 9, 2025
8:30 PM – 10:00 PM

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

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

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Alkurtass, Al Qattan, Al Refai, Al Smadi, Askar, Demir, Salameh, Zaman

Model Answer

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.**

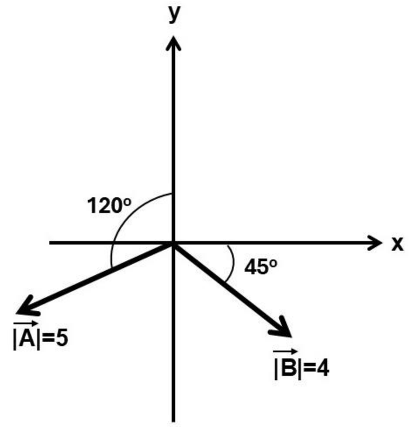
GOOD LUCK

Part I: Short Problems (2 points each)

SP1. Two vectors $\vec{A}$ and $\vec{B}$ are shown in the figure. **Write $\vec{A}$ and $\vec{B}$ in unit vector notation**.

$$\vec{\boldsymbol{A}} = -5cos30\,\hat{\imath} - 5sin30\,\hat{\jmath} = -4.33\,\hat{\imath} - 2.5\,\hat{\jmath}$$

$$\vec{\boldsymbol{B}} = 4cos45\hat{\imath} - 4sin45\hat{\jmath} = 2.83\,\hat{\imath} - 2.83\,\hat{\jmath}$$



SP2. Given the two vectors $\vec{\boldsymbol{A}} = (2\hat{\imath} - 4\hat{\jmath})$ and $\vec{\boldsymbol{B}} = (-2\hat{\imath} + 3\hat{\jmath})$, if $\vec{\boldsymbol{C}} = \vec{\boldsymbol{A}} + 2\vec{\boldsymbol{B}}$, **find the angle between $\vec{C}$ and the $+x$ axis**.

$$\vec{\boldsymbol{C}} = \vec{\boldsymbol{A}} + 2\vec{\boldsymbol{B}} = (2\hat{\imath} - 4\hat{\jmath}) + 2(-2\hat{\imath} + 3\hat{\jmath}) = -2\hat{\imath} + 2\hat{\jmath}$$

$$\alpha = tan^{-1}\left(\frac{2}{-2}\right) = -45^\circ$$

$\theta = 180 - 45 = 135^\circ$ CCW from +x axis

Or

$$\theta_x = cos^{-1}\left(\frac{C_x}{C}\right) = cos^{-1}\left(\frac{-2}{2\sqrt{2}}\right) = 135^\circ$$

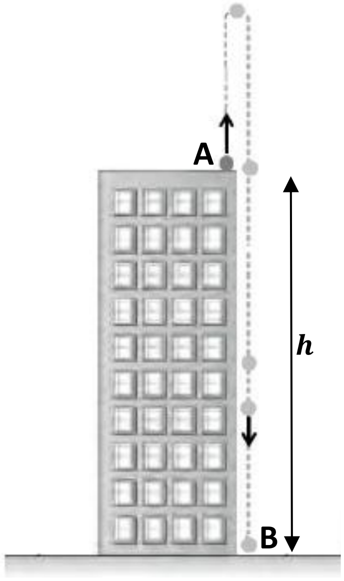
SP3. The position vector of a particle moving in the $xy - plane$ is given by: $\vec{r} = (2t - t^3)\hat{\imath} + (4t^2)\hat{\jmath}$ where t is measured in seconds and $\vec{r}$ is measured in meters. **Find the speed of the particle at $t = 2$ seconds**.

$$\vec{v} = \frac{d\vec{r}}{dt} = (2 - 3t^2)\hat{\imath} + 8t\hat{\jmath}$$

$$\vec{v}(t = 2) = (2 - 3(2)^2)\hat{\imath} + 8(2)\hat{\jmath} = (-10\hat{\imath} + 16\hat{\jmath})\ \text{m/s}$$

$$|\vec{v}(2)| = \sqrt{(-10)^2 + 16^2} \approx 18.9\ \text{m/s}$$

SP4. A ball is thrown **upward** with an initial velocity (v_0) from the top of a building with a height (h). It takes $t = 2s$ to reach its maximum height and then hits the ground at point **B** with a speed of $35\ m/s$. **What is the height of the building (h)?**



$v_y = v_{oy} + a_y t$

$0 = v_{oy} - gt$

$v_{oy} = gt = 10(2) = 20$ m/s

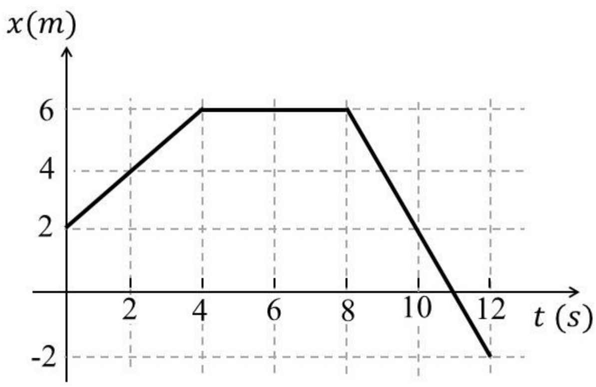
$v_f^2 = v_i^2 - 2g(y_f - y_i)$

$(-35)^2 = (20)^2 - 2 \times 10(y_f - 0)$

$y_f = -41.25\ m,$

$h = 41.25\ m$

SP5. The position-time graph of an object moving along the x-axis is shown in the figure. Find the **average acceleration** between ***t = 2 s* and *t = 10 s***.



$a_{av} = \frac{\Delta v}{\Delta t}$

$v_2 = \frac{-2-6}{12-8} = -2\ m/s$

$v_1 = \frac{6-2}{4-0} = 1\ m/s$

$a_{av} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{-2-1}{10-2} \approx -0.38$ m/s^2

Part II: Long Problems (3 points each)

LP1. Given two vectors: $\vec{\boldsymbol{A}} = (3\hat{\imath} - 4\hat{\jmath} + 4\hat{k})$ and $\vec{\boldsymbol{B}} = (2\hat{\imath} + 3\hat{\jmath} - 7\hat{k})$,

(a) Find $\vec{\boldsymbol{C}} = 2\vec{\boldsymbol{A}} - \vec{\boldsymbol{B}}$ in unit vector notation.

$$\vec{\boldsymbol{C}} = 2\vec{\boldsymbol{A}} - \vec{\boldsymbol{B}} = 2(3\hat{\imath} - 4\hat{\jmath} + 4\hat{k}) - (2\hat{\imath} + 3\hat{\jmath} - 7\hat{k})$$

$$\vec{\boldsymbol{C}} = 4\hat{\imath} - 11\hat{\jmath} + 15\hat{k}$$

(b) Find the vector product $\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}$.

$$\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 3 & -4 & 4 \\ 2 & 3 & -7 \end{vmatrix}$$

$$\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}} = 16\hat{\imath} + 29\hat{\jmath} + 17\hat{k}$$

(c) Find $\vec{\boldsymbol{C}} \cdot (\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}})$.

$$\vec{\boldsymbol{C}} \cdot (\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}) = 2\vec{A} \cdot (\vec{A} \times \vec{B}) - \vec{B} \cdot (\vec{A} \times \vec{B}) = 0 - 0 = 0$$

or

$$\vec{\boldsymbol{C}} \cdot (\vec{\boldsymbol{A}} \times \vec{\boldsymbol{B}}) = 4(16) - 11(29) + 15(17) = 0$$

LP2. An object moves along the **x-axis** with its position as a function of time given by: $x(t) = 4t - 0.125t^4$ where x is measured in $meters$ and t is measured in $seconds$.

(a) Find the **average velocity** between $\boldsymbol{t = 0\ s}$ **and** $\boldsymbol{t = 4\ s}$.

$$v_{av} = \frac{\Delta x}{\Delta t}$$

$$x_2 = 4(4) - 0.125(4)^4 = -16\ m$$

$$x_1 = 4(0) - 0.125(0)^4 = 0\ m$$

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{-16-0}{4-0} = -4 \text{ m/s}$$

(b) **Find the time** when the object **changes its direction of motion**.

$$v_x = \frac{dx}{dt} = 4 - 0.5t^3$$

$$v_x = 0$$

$$t = 2\ seconds$$

(c) Find the **average speed** of the object between $\boldsymbol{t = 0}$ **and** $\boldsymbol{t = 4\ s}$**.**

$$s_{av} = \frac{D}{\Delta t}$$

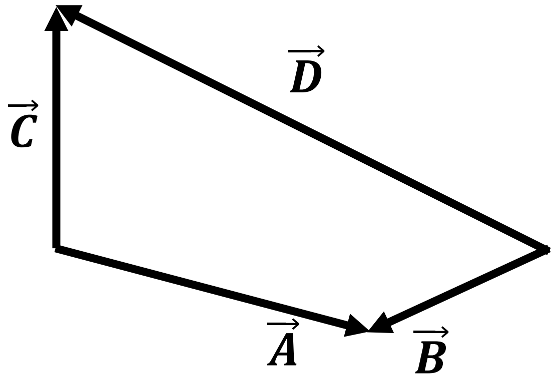
$$D_1 = x(2) - x(0) = 4(2) - 0.125(2)^4 = 8 - 2 = 6\ m$$

$$D_2 = |x(4) - x(2)| = |-16 - 6| = 22\ m$$

$$s_{av} = \frac{D}{\Delta t} = \frac{6 + 22}{4 - 0} = 7\ m/s$$

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

Q1. Which of the following relations describes the vector $\vec{A}$ in the figure?



* $\vec{A} = \vec{B} + \vec{C} + \vec{D}$
* $\vec{A} = \vec{B} + \vec{C} - \vec{D}$
* $\vec{A} = \vec{B} - \vec{C} - \vec{D}$
* $\vec{A} = \vec{B} - \vec{C} + \vec{D}$

Q2. An object is moving **along a straight line**. Which of the following is true if the object **is speeding up**?

* $v > 0, a < 0$
* $v = 0, a = 0$
* $v < 0, a < 0$
* $v < 0, a > 0$

Q3. The value of $\hat{\imath} \cdot (\hat{k} \times \hat{\jmath})$ is

* -1 * $+1$ * 0 * $\hat{\imath}$

Q4. The velocity and acceleration of an object at a certain instant are:

$$\vec{v} = -2\,\hat{\jmath}\; m/s; \qquad \vec{a} = (3\hat{\imath} + 4\hat{\jmath})\; m/s^2.$$

At this instant, the object is

* moving in a straight line and slowing down.
* moving in a curved path and slowing down.
* moving in a straight line and speeding up.
* moving in a curved path and speeding up.