Kuwait University Physics Department

Physics 101

Summer Semester

First Midterm Exam

Saturday, July 2, 2022

9:00 AM – 10:30 AM

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

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Dr. Abdul Khaleq
Dr. Belal Salameh
Dr. Fatema Al Dosari

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	SP6	LP1	LP2	Q1	Q2	Q3	Q4	Q5	Total
Pts	2	2	2	2	2	2	4	4	1	1	1	1	1	25

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 25 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 particle moves along the positive x-axis with **constant acceleration.** It starts moving **from the origin** with a speed of 3 m/s and **reaches $x = 8\ m$ after 2 s. Find the particle's acceleration.**

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

$$8 = 3(2) + \frac{1}{2}a_x(2)^2$$

$$a_x = 1\ m/s^2$$

SP2. A particle moves along the x-axis. Its position is given by $x(t) = t^3 - 12t$, where x is in m and t is in s. **Find the acceleration of the particle <u>when it changes its direction of motion.</u>**

$$v_x(t) = \frac{dx}{dt} = 3t^2 - 12$$

$$v_x(t) = 3t^2 - 12 = 0 \Rightarrow t = 2s$$

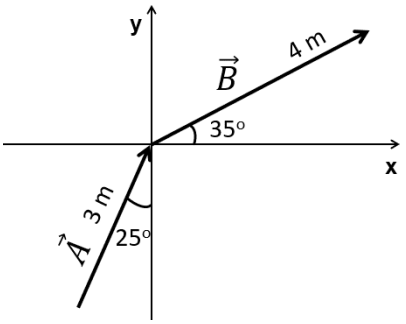
$$a_x(t) = \frac{dv_x}{dt} = 6t$$

$$a_x(t = 2s) = 6(2) = 12\ m/s^2$$

SP3. Vectors $\vec{A}$ and $\vec{B}$ lie in the xy-plane, as shown. **Find $\vec{A} \times \vec{B}$.**

$$|\vec{A} \times \vec{B}| = |\vec{A}||\vec{B}| \sin\varphi = (3)(4)\sin(30^o) = 6$$

$$\vec{A} \times \vec{B} = -6\,\hat{k}$$



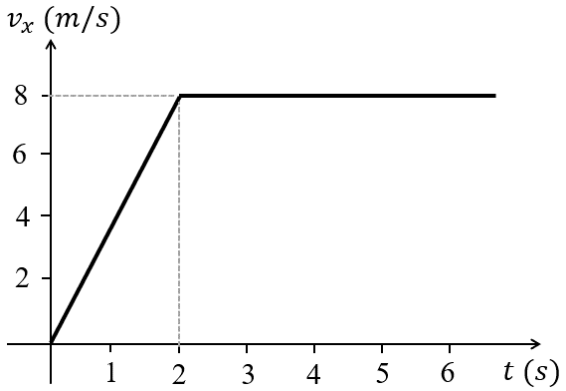
SP4. A particle is moving in the xy-plane. Its position is given by $x(t) = 3t^2 - 6t,\ y(t) = -4t^3 + 36t$, where x and y are in m and t is in s. **Find the speed of the particle at $t = 2\ s$.**

$$v_x(t) = \frac{dx}{dt} = 6t - 6 \Rightarrow v_x(t = 2\ s) = 6\ m/s$$

$$v_y(t) = \frac{dy}{dt} = -12t^2 + 36 \Rightarrow v_y(t = 2\ s) = -12\ m/s$$

$$v(t = 2\ s) = \sqrt{6^2 + (-12^2)} = 13.4\ m/s$$

SP5. The velocity of a particle moving along the x-axis as a function of time is shown. **Find the average speed of the particle between $t = 0\ s$ and $t = 5\ s$ is:**



$$d = Area = \frac{1}{2}(2)(8) + (3)(8) = 32\ m$$

$$v_{av} = \frac{d}{t} = \frac{32}{5} = 6.4\ m/s$$

SP6. A car starts **from the origin** and moves 25 km west in 10 minutes, then 40 km in a direction 37° north of west in 20 minutes. **Find the <u>average velocity</u> of the car in unit vector notation.**

$$\vec{A} = -25\hat{\imath}\ km$$

$$\vec{B} = -40\cos(37^o)\,\hat{\imath} + 40\sin(37^o)\hat{\jmath} = (-32\hat{\imath} + 24.1\hat{\jmath})\ km$$

$$\vec{R} = \vec{A} + \vec{B} = (-57\hat{\imath} + 24.1\hat{\jmath})\ km$$

$$\vec{v}_{av} = \frac{\vec{R}}{t} = (-114\hat{\imath} + 48.2\hat{\jmath})\ km/hr$$

Part II: Long Problems (4 points each)

LP1. Two vectors are given by: $\vec{A} = 3\hat{\imath} - 4\hat{\jmath} + 2\hat{k}$ and $\vec{B} = 2\hat{\imath} + 6\hat{\jmath} - 4\hat{k}$

a) Find the angle between $\vec{A}$ and $\vec{B}$.

$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos(\varphi)$

$$\varphi = cos^{-1}\left(\frac{\vec{A} \cdot \vec{B}}{|\vec{A}||\vec{B}|}\right) = cos^{-1}\left(\frac{(3)(2) + (-4)(6) + (2)(-4)}{\sqrt{9+16+4}\ \sqrt{4+36+16}}\right) = cos^{-1}\left(\frac{-26}{\sqrt{29}\ \sqrt{56}}\right) = 130.2^o$$

b) Find $|2\vec{A} - \vec{B}|$.

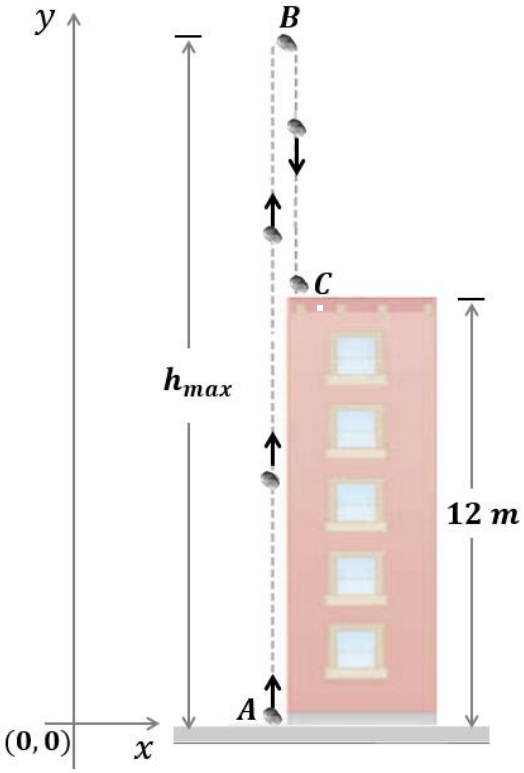
$$2\vec{A} - \vec{B} = 2(3\hat{\imath} - 4\hat{\jmath} + 2\hat{k}) - (2\hat{\imath} + 6\hat{\jmath} - 4\hat{k}) = (6\hat{\imath} - 8\hat{\jmath} + 4\hat{k}) - (2\hat{\imath} + 6\hat{\jmath} - 4\hat{k}) = (4\hat{\imath} - 14\hat{\jmath} + 8\hat{k})$$

$$|2\vec{A} - \vec{B}| = \sqrt{4^2 + 14^2 + 8^2} = 16.6$$

c) If $\vec{C} = 2\hat{\imath} + C_y\hat{\jmath}$ and $\vec{C}$ is perpendicular to $\vec{A}$, find the value of C_y.

$\vec{A} \cdot \vec{C} = (3)(2) + (-4)(C_y) = 0 \Rightarrow C_y = 1.5$

LP2. A stone is thrown **vertically upward** from point A and reaches the maximum height (at point B), then hits the roof (at point C), as shown. The stone moves from point A to point C in $2s$.



a) Find the initial speed of the stone (at point A).

(From the ground to the roof)

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

$12 = v_{y_i}(2) - 5(2^2) \Rightarrow v_{y_i} = 16\, m/s$

b) Find the maximum height (h_{max}) of the stone.

(From the ground to the maximum height)

$v_{y_f}^2 = v_{y_i}^2 - 2g\Delta y$

$0 = 16^2 - 20\, h_{max} \;\Rightarrow\; h_{max} = 12.8\, m$

c) Find the time needed for the stone to reach its maximum height.

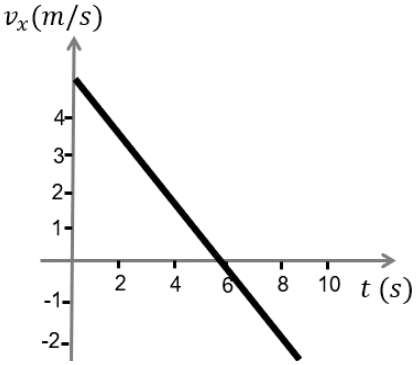
(From the ground to the maximum height)

$v_{y_f} = v_{y_i} - gt$

$0 = 16 - 10t \Longrightarrow t = 1.6\, s$

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

Q1. The velocity of a particle moving along the x-axis as a function of time is shown. The **speed** of this particle is:



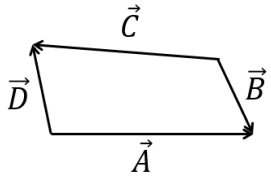
(*) decreasing then increasing.

* increasing then decreasing.

* always increasing.

* always decreasing.

Q2. The figure which satisfies the relation $\vec{A} = \vec{B} - \vec{C} - \vec{D}$ is:



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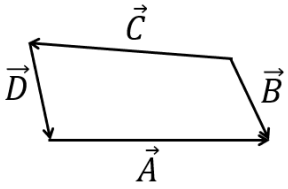

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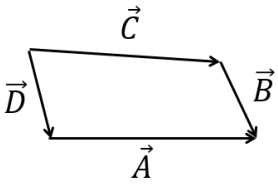

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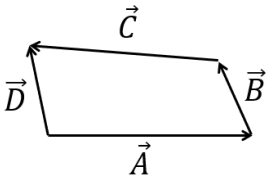

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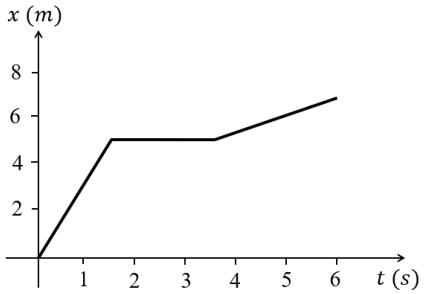
Q3. If $\vec{A} = a\hat{\imath} + b\hat{\jmath} - c\hat{k}$ and $\vec{B} = -2a\hat{\imath} - 2b\hat{\jmath} + 2c\hat{k}$, where a, b, and c are constants. **The angle between $\vec{A}$ and $\vec{B}$ is**

* $zero$ * 90^o (*) 180^o * 270^o

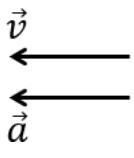
Q4. The position of a particle moving along the x-axis as a function of time is shown. **The average acceleration of the particle between $t = 1\ s$ and $t = 5\ s$ is:**



(*) negative * positive

* Zero * cannot be determined

Q5. The velocity and the acceleration vectors for 4 moving particles, at one instant, are shown. **Which of the following represents the particle which moves to the east and slows down?**



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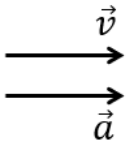

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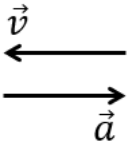

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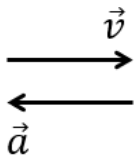

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