Kuwait University Physics Department

Physics 101

Summer Semester

First Midterm Exam

Sunday, August 15, 2021

6:30 pm – 08:00 pm

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

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Dr. Hala Al-Jassar
Dr. Fatema Al Dosari
Dr. Tareq Al Refai
Dr. Abdul Khaleq
Dr. Belal Salameh

For Instructors use only

Grades:

#	Q1	Q2	Q3	Q4	Q5	SP1	SP2	SP3	SP4	SP5	LP1	LP2	Total
Pts	1	1	1	1	1	3	3	3	3	3	5	5	30

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 30 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.**

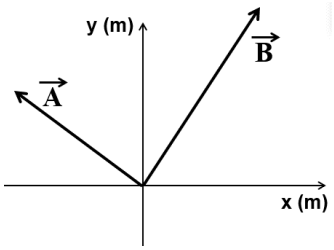
GOOD LUCK

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

Q1. It takes time **t** for a ball to reach the ground when dropped from a height of **h**. **How long does it take the same ball (in terms of t) to reach the ground when dropped from a height of 4h? Ignore air resistance.**

* 8t * $4t$ (*) $2t$ *$\sqrt{2}\,t$

Q2. The figure shows the vectors $\vec{A}$ and $\vec{B}$. **If α is the angle between the vector $\vec{R} = \vec{A} - \vec{B}$ and the positive x-axis then.**



* $0^o < \alpha < 90^o$ (*) $180^o < \alpha < 270^o$
* $270^o < \alpha < 360^o$ * $\alpha = 90^o$

Q3. If $\vec{A} = 4\hat{\imath} + 5\hat{\jmath}$, which of the following vectors satisfy the relation $\vec{A} \cdot \vec{B} = 0$

* $\vec{B} = 3\hat{\imath}$ * $\vec{B} = 7\hat{\jmath}$ * $\vec{B} = 2\hat{\imath} + 5\hat{k}$ (*) $\vec{B} = -3\hat{k}$

Q4. A ball is released from the top of a tall building. At the same instant, a stone is thrown upward from the ground level. **When the ball and the stone pass each other, one of the following statements is correct.**

* The acceleration of the ball is greater.
* The acceleration of the stone is greater.
(*) The accelerations have the same magnitude and direction.
* The accelerations have the same magnitude and opposite directions.

Q5. When is the average velocity of an object equal to the instantaneous velocity?

* always * never
(*) only when the velocity is constant * only when the velocity is increasing at a constant rate

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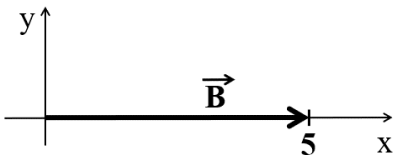
Part II: Short Problems (3 points each)

SP1: Given the two vectors $\vec{A}$ and $\vec{B}$, where $\vec{A} = 2\hat{\imath} + 3\hat{\jmath} + 5\hat{k}$ and $\vec{B}$ is shown in the figure. **Find $\vec{A} \times \vec{B}$.**

$\vec{B} = 5\hat{\imath}$



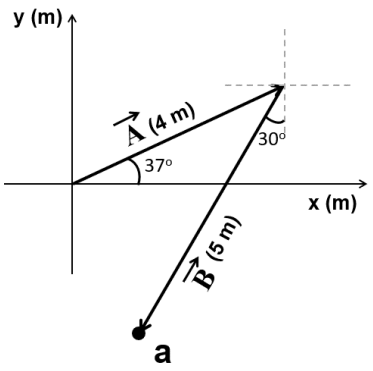
$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 2 & 3 & 5 \\ 5 & 0 & 0 \end{vmatrix}$$

$$= \hat{\imath}(0 - 0) + \hat{\jmath}(25 - 0) + \hat{k}(0 - 15)$$

$$= 25\hat{\jmath} - 15\hat{k}$$

Answer: $\vec{A} \times \vec{B} = 25\hat{\jmath} - 15\hat{k}$

SP2. An object starts moving from the origin. It moves along the vector $\vec{A}$ and then along the vector $\vec{B}$ as shown. **Find the distance <u>between point a and the origin.</u>**



$\vec{A} = 4\cos(37^o)\,\hat{\imath} + 4\sin(37^o)\,\hat{\jmath} = (3.2\hat{\imath} + 2.4\hat{\jmath})\ m$

$\vec{B} = -5\sin(30^o)\,\hat{\imath} - 5\cos(30^o)\,\hat{\jmath} = (-2.5\hat{\imath} - 4.3\hat{\jmath})\ m$

$\vec{R} = \vec{A} + \vec{B} = (0.7\hat{\imath} - 1.9\hat{\jmath})\ m$

$|\vec{R}| = \sqrt{0.7^2 + 1.9^2} = 2.0\ m$

Answer: $|\vec{R}| = 2.0\ m$

SP3. Ali runs at a constant speed of 5 m/s along a straight line from point A to point B. He then runs back from point B to point A at a constant speed of 3 m/s. **Find Ali's average speed for the entire trip.**

$5 = \frac{d}{t_1} \Rightarrow t_1 = \frac{d}{5}$

$3 = \frac{d}{t_2} \Rightarrow t_2 = \frac{d}{3}$

$v_{av} = \frac{2d}{t_1 + t_2} = \frac{2d}{\frac{d}{5} + \frac{d}{3}} = \frac{30d}{8d} = 3.75\ m/s$

Answer: $v_{av} = 3.75\ m/s$

SP4. The position of a particle moving along the x-axis is given by: $x(t) = (2t^2 - t^3)\ m$, where t is in seconds. **Calculate the <u>average acceleration</u> of the particle during the interval from $\boldsymbol{t = 2\ s}$ to $\boldsymbol{t = 4\ s}$.**

$v_x(t) = \frac{dx}{dt} = (4t - 3t^2)\ m/s$

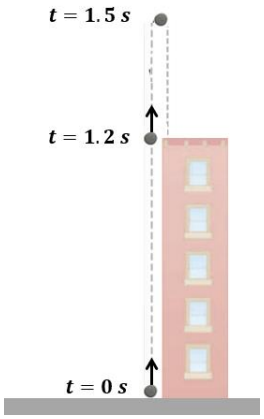
$v_x(2s) = 4(2) - 3(2)^2 = -4\ m/s$

$v_x(4s) = 4(4) - 3(4)^2 = -32\ m/s$

$a_{av-x} = \frac{v_x(4s) - v_x(2s)}{2} = -14\ m/s^2$

Answer: $a_{av-x} = -18\ m/s^2$

SP5. A stone is thrown vertically upward from the ground level at $t = 0\ s$. At $t = 1.2\ s$ it passes the top of a tall building and at $t = 1.5\ s$ it reaches its maximum height. **What is the height of the building?**



$v_y = v_{y_o} - gt$

$0 = v_{y_o} - 10(1.5) \Rightarrow v_{y_o} = 15\ m/s$

$\Delta y = v_{y_o} t - \frac{1}{2} g t^2 = 15(1.2) - 5(1.2^2) = 10.8\ m$

$h = 10.8\ m$

Answer: $h = 10.8\ m$

Part III: Long Problems (5 points each)

LP1. If $\vec{A} = 2\hat{\imath} + 3\hat{\jmath} - 4\hat{k}$, $\vec{B} = 5\hat{\imath} - 6\hat{\jmath} + 2\hat{k}$. Find:

a) $\left|2\vec{A} - \vec{B}\right|$

$2\vec{A} - \vec{B} = (4-5)\hat{\imath} + \big(6-(-6)\big)\hat{\jmath} + (-8-2)\hat{k} = -1\hat{\imath} + 12\hat{\jmath} - 10\hat{k}$

$\left|2\vec{A} - \vec{B}\right| = \sqrt{1^2 + 12^2 + 10^2} = 15.7$

Answer: $\left|2\vec{A} - \vec{B}\right| = 15.7$

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

$$\varphi = cos^{-1}\left(\frac{\vec{A}\cdot\vec{B}}{|\vec{A}||\vec{B}|}\right) = cos^{-1}\left(\frac{(2)(5)+(3)(-6)+(-4)(2)}{\sqrt{29}\sqrt{65}}\right) = cos^{-1}\left(\frac{-16}{\sqrt{29}\sqrt{65}}\right) = 111.6^o$$

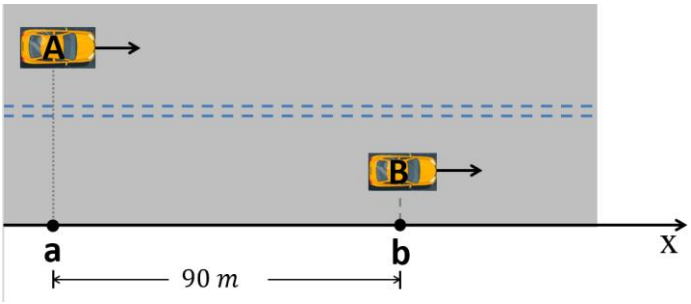
Answer: $\varphi = 111.6^o$

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

$$\beta = cos^{-1}\left(\frac{A_y}{|\vec{A}|}\right) = cos^{-1}\left(\frac{3}{\sqrt{29}}\right) = 56.1^o$$

Answer: $\beta = 56.1^o$

LP2. At $t = 0\ s,$ car A starts from rest at **point a** moving along the positive x-axis with constant acceleration of $3\ m/s^2$. At the same instant, car B starts from **point b** moving along the positive x-axis with constant speed of 14 m/s as shown.



a) At what time car A will overtake car B?

$$\Delta x_A = 90 + \Delta x_B$$

$$v_{A_o}t + \frac{1}{2}a_A t^2 = 90 + v_{B_o}t + \frac{1}{2}a_B t^2$$

$$0 + \frac{1}{2}(3)t^2 = 90 + 14t + 0$$

$$1.5t^2 - 14t - 90 = 0 \Rightarrow t = 13.7\ s$$

Answer: $t = 13.7\ s$

b) What is the speed of car A when it overtakes car B?

$$v_A = v_{A_o} + a_A t = 0 + 3(13.7) = 41.1\ m/s$$

Answer: $v_A = 41.1\ m/s$

c) What is the distance between the two cars at $t = 12\ s$?

$$d = x_B - x_A = \left(90 + v_{B_o}t + \frac{1}{2}a_B t^2\right) - (v_{A_o}t + \frac{1}{2}a_A t^2)$$

$$= (90 + 14(12) + 0) - (0 + \frac{1}{2}(3)(12^2) = 42\ m$$

Answer: $d = 42\ m$