Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Summer Semester
First Midterm Exam
Saturday, June 24, 2023
9:00 AM – 10:30 AM

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

Model Answer

Student's Number: …… Section: ……

Instructors: Drs. Al Dosari, Al Jassar, Al Smadi, Salameh

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 x-axis. Its position is given by $x(t) = t^2 - 6t + 8$, where x is in m and t is in s. **Find the average velocity of the particle during the period from $t = 1\ s$ to $t = 4\ s$.**

$x_i = x(t = 1\ s) = 1^2 - 6(1) + 8 = 3\ m$

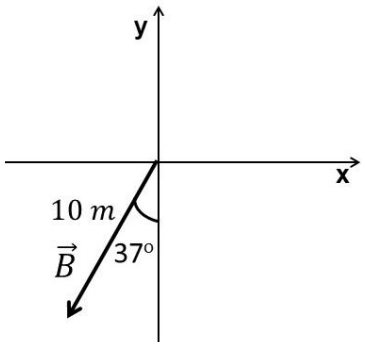
$x_f = x(t = 4\ s) = 4^2 - 6(4) + 8 = 0\ m$

$$v_{av-x} = \frac{x_f - x_i}{\Delta t} = \frac{0 - 3}{3} = -1\ m/s$$

SP2. If $\overrightarrow{A} = (2\hat{\imath} - 4\hat{\jmath} + 3\hat{k})\ m$ and $\overrightarrow{B}$ is shown in the figure. **Find $\overrightarrow{A} + \overrightarrow{B}$ in unit vector notation.**

$\overrightarrow{\mathrm{B}} = (-10 \sin 37^o\ \hat{\imath} - 10 \cos 37^o\ \hat{\jmath})\ m = (-6\hat{\imath} - 8\hat{\jmath})\ m$

$\overrightarrow{\mathrm{A}} + \overrightarrow{\mathrm{B}} = (2 - 6)\hat{\imath} + (-4 - 8)\ \hat{\jmath} + (3 + 0)\ \hat{k} = \left(-4\hat{\imath} - 12\hat{\jmath} + 3\hat{k}\right) m$



SP3. The position vector of a particle moving in the xy-plane is given by $\vec{r}(t) = (7 + 3t^3)\ \hat{\imath} + (6t - 5t^2)\ \hat{\jmath}$, where r is measured in *m* and *t* in *s*. **Find the acceleration of the particle at $t = 2s$ in unit vector notation.**

$$\vec{v}(t) = \frac{d\vec{r}(t)}{dt} = 9t^2\ \hat{\imath} + (6 - 10t)\ \hat{\jmath}$$

$$\vec{a}(t) = \frac{d\vec{v}(t)}{dt} = 18t\hat{\imath} - 10\ \hat{\jmath}$$

$\vec{a}(2s) = (36\ \hat{\imath} - 10\ \hat{\jmath})\ m/s^2$

SP4. A car **accelerates uniformly <u>from rest</u>** along a straight line and covers 80 m in 8 seconds. **Determine the final speed of the car (at $t = 8s$).**

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

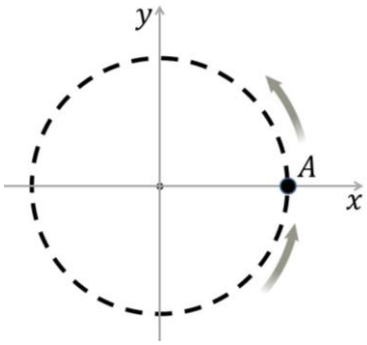
$$80 = 0 + \frac{1}{2} a_x 8^2 \Rightarrow a_x = 2.5\ m/s^2$$

$$v_{x_f} = v_{x_i} + a_x t = 0 + (2.5)(8) = 20\ m/s$$

SP5. A particle moves counterclockwise in a circular path of radius $R = 2\ m$, as shown. The particle's speed at point A is 4 m/s, and it is slowing down at a rate of 3 m/s^2. **Find the <u>total acceleration</u> of the particle at point A in unit vector notation.**

$$a_c = \frac{v^2}{R} = \frac{4^2}{2} = 8\ m/s^2$$

$$\vec{a} = (-8i - 3j)\ m/s^2$$



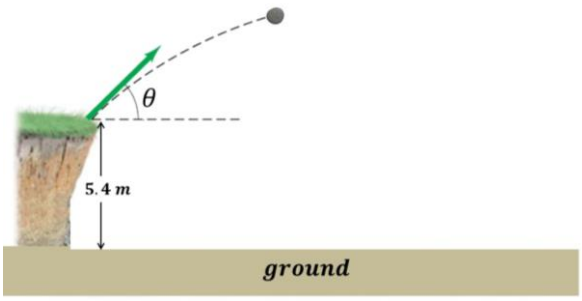
SP6. A stone is projected from the edge of a cliff at an angle θ above the horizontal, as shown. It **reaches the <u>ground</u>** with velocity $\vec{v} = (8\,\hat{\imath} - 12\hat{\jmath})\ m/s$. **Find the value of θ.**

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

$$(-12)^2 = v_{y_i}^2 - 2(10)(-5.4) \Rightarrow v_{y_i} = 6\ m/s$$

$$\vec{v}_i = (8\,\hat{\imath} + 6\hat{\jmath})\ m/s$$

$$\theta = tan^{-1}\left(\frac{v_{i_y}}{v_{i_x}}\right) = 36.9^o$$



Part II: Long Problems (4 points each)

LP1. Given the two vectors $\vec{A} = 4\hat{\imath} + 2\hat{\jmath} - 3\hat{k}$ and $\vec{B} = 3\hat{\imath} - 5\hat{\jmath} + 2\hat{k}$

a) Find $2\vec{A} \cdot \vec{B}$

$2\vec{A} \cdot \vec{B} = (8)(3) + (4)(-5) + (-6)(2) = -8$

b) Vector $\vec{C}$ is perpendicular to both $\overrightarrow{\mathrm{A}}$ and $\overrightarrow{\mathrm{B}}$. Find $\vec{C}$ in unit vector notation.

$$\vec{C} = \overrightarrow{\mathrm{A}} \times \overrightarrow{\mathrm{B}} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 4 & 2 & -3 \\ 3 & -5 & 2 \end{vmatrix}$$

$$= (4 - 15)\hat{\imath} + (-9 - 8)\,\hat{\jmath} + (-20 - 6)\,\hat{k} = -11\,\hat{\imath} - 17\,\hat{\jmath} - 26\,\hat{k}$$

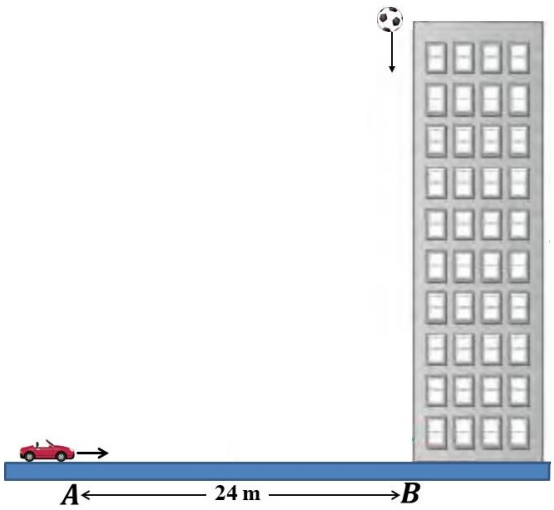
c) Find the angle between $\vec{A}$ and the <u>negative</u> x-axis.

$$\alpha = cos^{-1}\left(\frac{A_x}{|\vec{A}|}\right) = cos^{-1}\left(\frac{4}{\sqrt{4^2 + 2^2 + 3^2}}\right) = 42^o$$

$$the\ angle\ between\ \vec{A}\ and\ the\ negative\ x - axis\ = 180 - \alpha = 138^o$$

LP2. A toy car starts at point A **from rest** and moves with constant acceleration of $3\,m/s^2$ along the $+x-axis$, at the same instant a ball is released **from rest** from the top of a building, as shown. The ball hits the car at point B.

a) How much time will it take the car to reach point B?



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

$$24 = 0 + \frac{1}{2}(3)t^2 \Rightarrow t = 4s$$

b) Find the height of the building.

$$\Delta y = v_{y_i}t - \frac{1}{2}gt^2 = 0 - 5(4^2) = -80\,m \Rightarrow h = 80\,m$$

c) Find the velocity of the ball just before it hits the car.

$$v_{y_f} = v_{y_i} - gt = 0 - (10)(4) = -40\,m/s$$

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

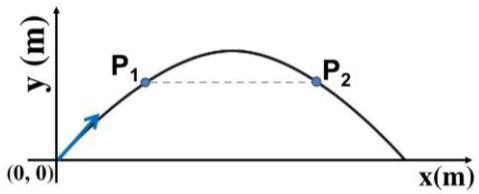
Q1. If $|\vec{A}+\vec{B}| = |\vec{C}|$ and $|\vec{A}| + |\vec{B}| = |\vec{C}|$, then

* $\vec{A}$ is perpendicular to $\vec{B}$
* (*) $\vec{A}$ is parallel to $\vec{B}$
* $\vec{A}$ is anti parallel to $\vec{B}$
* The angle between $\vec{A}$ and $\vec{B}$ is 45°

Q2. A particle is **speeding up** while traveling along **the negative x-axis**, then

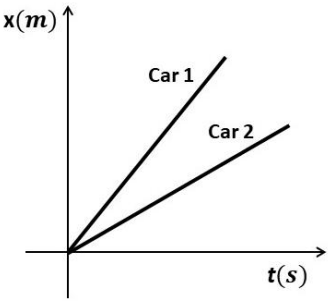
* v_x is positive and a_x is positive.
* v_x is negative and a_x is positive.
* (*) v_x is negative and a_x is negative.
* v_x is positive and a_x is negative.

Q3. The trajectory of a projectile is shown in the figure. If the velocity and the acceleration of the projectile **at point P2** respectively, are: $\vec{v}_2 = (5\hat{\imath} - 8\hat{\jmath})m/s$ and $\vec{a}_2 = (0\hat{\imath} - 10\hat{\jmath})m/s^2$, **then the velocity and the acceleration of the projectile at point P1 respectively, are:**



* (*) $\vec{v}_1 = (5\hat{\imath} + 8\hat{\jmath})m/s$ and $\vec{a}_1 = (0\hat{\imath} - 10\hat{\jmath})m/s^2$
* $\vec{v}_1 = (5\hat{\imath} + 8\hat{\jmath})m/s$ and $\vec{a}_1 = (0\hat{\imath} + 10\hat{\jmath})m/s^2$
* $\vec{v}_1 = (5\hat{\imath} - 8\hat{\jmath})m/s$ and $\vec{a}_1 = (0\hat{\imath} - 10\hat{\jmath})m/s^2$
* $\vec{v}_1 = (5\hat{\imath} - 8\hat{\jmath})m/s$ and $\vec{a}_1 = (0\hat{\imath} + 10\hat{\jmath})m/s^2$

Q4. The position - time graph of two cars travelling along the x-ais is shown. **The speed difference between the two cars ($v_{x_1} - v_{x_2}$) over time will**



* increase
* decrease
* (*) be constant
* be zero

Q5. A particle moves in a circular path, the magnitude of its radial acceleration is $|a_R| = 4\ m/s^2$ and the magnitude its total acceleration is $|a_{total}| = 5\ m/s^2$, **then one of the following sentences is true.**

* The particle must be speeding up
* The particle must be slowing down
* The particle is moving with constant speed
* (*) The particle is either speeding up or slowing down