Kuwait University **Physics Department**

Physics 101

Fall Semester
1st Midterm Exam
Saturday, October 29, 2016
09:00 – 11:00 a.m.

Student's Name: ……

Student's Number: …… Section: ……

Choose your Instructor's Name:

Prof. Yacoub Makdisi	Dr. Abdul Mohsen
Dr. Hasan Raafat	Dr. Tareq Al Refai
Dr. Hala Al-Jassar	Dr. Belal Salameh
Dr. Ahmed Al-Jassar	Dr. Nasser Demir
Dr. Fatema Al Dosari	Dr. Abdul Khaleq

Grades: **For Instructors use only**

#	Q1	Q2	Q3	Q4	Q5	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	SP10	SP11	LP1	LP2	Total
Pts	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	20

Important:

1. Answer all questions and problems.
2. Full mark = 20 points as arranged in the above table.
   i. 5 **Q**uestions
   ii. 11 **S**hort **P**roblems
   iii. 2 **L**ong **P**roblems.
3. No solution = no points.
4. **Use SI units.**
5. Check the correct answer for each question.
6. Assume g = 10 m/s^2.
7. Mobiles are **strictly prohibited** during the exam.
8. Programmable calculators, which can store equations, are not allowed.
9. **Please write down your final answer in the box shown in each problem**.
10. **Cheating accidents will be processed according to the university rules.**

GOOD LUCK

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

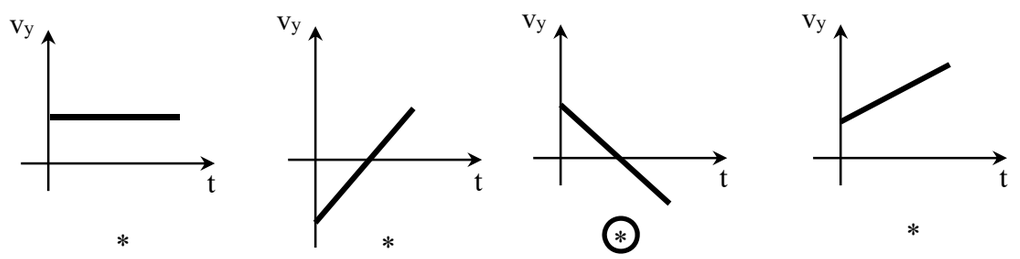
Q1. If the magnitude of ($\vec{A}+\vec{B}$) is less than the magnitude of $\vec{A}$, then

- (*) $\vec{A}\cdot\vec{B}$ must be negative
- * $\vec{A}\cdot\vec{B}$ must be positive
- * The vector $\vec{A}$ must be perpendicular to the vector $\vec{B}$
- * The vector $\vec{A}$ must be parallel to the vector $\vec{B}$

Q2. A ball is thrown directly upward. Ignore air resistance. **The direction of the acceleration of the ball**

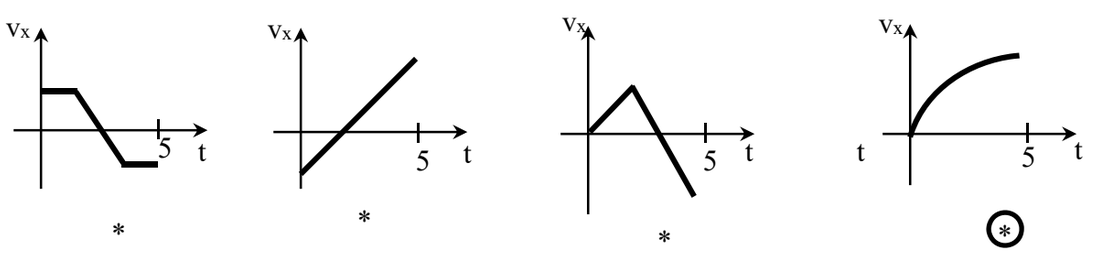
- * is upward while it is travelling up and downward while it is travelling down.
- * is downward while it is travelling up and upward while it is travelling down.
- * is downward, except at the maximum height when it is zero.
- (*) always downward.

Q3. A stone is thrown vertically **upward**. T**he graph which represents the stone velocity (v_y) versus time (t) is:**



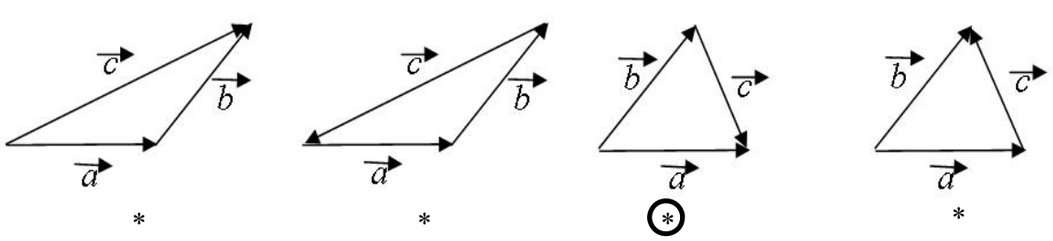
* * (*) *

Q4. A particle moving from the origin along the x-axis reaches the largest displacement from the origin at $t = 5\ s$. T**he graph which represents the velocity (v_x) of the particle versus time (t) is:**



* * * (*)

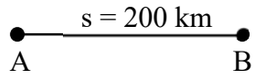
Q5. The vectors $\vec{a}$, $\vec{b}$, and $\vec{c}$ are related by $\vec{c} = \vec{a} - \vec{b}$. **Which diagram below illustrates this relationship?**



* * (*) *

Part II: Short Problems (1 point each)

SP1. Two cars make simultaneously a 200 km trip from city A to city B. The small car arrives city B one hour before the big car. If the average speed of the big car is 40 km/h, **what is the average speed (in km/h) of the small car?**

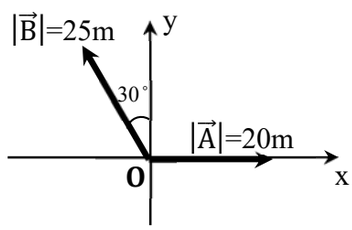


$\bar{v}_s = 40 = \frac{200}{t} \rightarrow \ t = 5h$

$\bar{v}_b = \frac{200}{4} = 50\ km/h$

Answer: 50 km/h

SP2. Three boys are playing in a football field. Osama (O) is located at the center of the field. The position vectors of Ali ($\vec{A}$) and Bader ($\vec{B}$) are shown. **Find the distance (in m) between Ali and Bader.**



$\vec{A} = 20\,\hat{\imath}$

$\vec{B} = -25cos60\hat{\imath} + 25sin\,60\hat{\jmath}$

$= -12.5\,\hat{\imath} + 21.65\,\hat{\jmath}$

$\vec{A} - \vec{B} = 32.5\hat{\imath} - 21.65\,\hat{\jmath}$

distance $= \left|\vec{A} - \vec{B}\right| = \sqrt{(32.5)^2 + (-21.65)^2}$

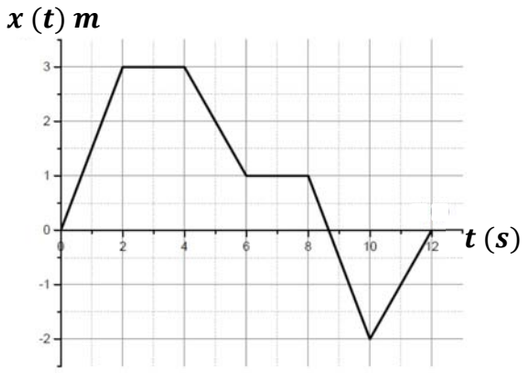
$= 39\ m$

(or) distance $= \sqrt{(20)^2 + (25)^2 - 2(20)(25)\cos 120}$

$= 39\ m$

Answer: $39\ m$

SP3. **A position-time (x-t) graph** for a particle moving along the x-axis is shown in the figure. **Find the average velocity (in m/s) in the time interval t = 0 to t = 6 s.**



$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{1-0}{6-0} = \frac{1}{6}$

$= 0.166\ m/s$

Answer: $0.1667\ m/s$

SP4. Vector, $\vec{B}$, when added to the vector $\vec{C} = (3\hat{\imath} + 4\hat{\jmath})$ yields a resultant vector which is in the positive y direction and has a magnitude equal to that of $\vec{C}$. **What is the vector $\vec{B}$ (in unit vector notation)?**

$\left|\vec{C}\right| = \sqrt{3^2 + 4^2} = 5$

$\vec{B} + \vec{C} = 5\,\hat{\jmath}$

$\vec{B} = 5\,\hat{\jmath} - (3\hat{\imath} + 4\hat{\jmath})$

$= -3\hat{\imath} + \hat{\jmath}$

Answer: $-3\hat{\imath} + \hat{\jmath}$

SP5. A particle moving along the x-axis has a position given by $x = (24t - 2t^3)m$, where t is in s.

What is the acceleration (in $\mathbf{m/s^2}$) at the moment the particle changes its direction?

$$v = \frac{dx}{dt} = 24 - 6t^2 = 0 \implies t = 2s$$

$$\boldsymbol{a} = \frac{dv}{dt} = -12t$$

$$a\,(2) = -24\ m/s^2$$

Answer: $-24\ m/s^2$

SP6. If vectors $\vec{A} = \left(\hat{\imath} - 2\hat{\jmath} + \hat{k}\right)$ and $\vec{B} = \left(-3\hat{\imath} + \hat{\jmath} + B_z\hat{k}\right)$ are **perpendicular**. **Find the value of $\boldsymbol{B_z}$.**

$$\vec{A} \cdot \vec{B} = 0 \implies -3 - 2 + B_z = 0$$

$$\implies B_z = 5$$

Answer: 5

SP7. An object initially at the origin has a velocity $\overrightarrow{v_i} = (4\hat{\imath} - 6\hat{\jmath})\ m/s$, 10 seconds later the object has a velocity of $\overrightarrow{v_f} = (8\hat{\imath} - 9\hat{\jmath})\ m/s$. **Find the average acceleration (in $\mathbf{m/s^2}$) of the object, in unit vector notation.**

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{10} = \frac{4\hat{\imath} - 3\hat{\jmath}}{10}$$

$$\vec{a} = 0.4\hat{\imath} - 0.3\,\hat{\jmath}\ m/s^2$$

Answer: $(0.4\hat{\imath} - 0.3\,\hat{\jmath})\ m/s^2$

SP8. In problem **SP7**, assume the object is moving with constant acceleration. **Find the magnitude of the displacement of the object from t = 0.0 to t = 10 s.**

$$\Delta\vec{r} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2 = (4\hat{\imath} - 6\hat{\jmath}) * 10 + \frac{1}{2}(0.4\hat{\imath} - 0.3\,\hat{\jmath}) * 10^2$$

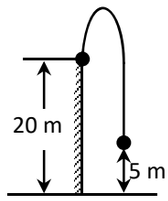
$$\Delta\vec{r} = 60\hat{\imath} - 75\,\hat{\jmath}$$

$$d = |\Delta\vec{r}| = \sqrt{(60)^2 + (-75)^2} = 96\ m$$

Answer: 96 m

SP9. A stone is thrown vertically upward with a speed of 12 m/s from the top of a building that is 20 m height. **Find the velocity (in m/s) of the stone when it is 5 m above the ground.**

$$v_f^2 = v_i^2 - 2g(y_f - y_i)$$
$$= 12^2 - 2(10)(-15 - 0)$$
$$v_f = -21\ m/s$$



Answer: $-21\ m/s$

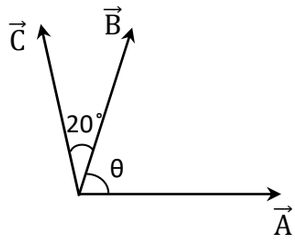
SP10. A ball is thrown vertically upward from the ground level with a speed of 20 m/s. One second later, a stone is thrown vertically upward with a speed of 25 m/s, from the same level. **At what height above the ground will the ball and the stone pass each other?**

$$y = y_i + v_i t - \frac{1}{2}gt^2$$
$$y_b = y_s$$
$$20\,t - 5t^2 = 25(t-1) - 5(t-1)^2$$
$$t = 2s$$
$$\Longrightarrow y = 20(2) - 5(2)^2 = 20m$$

Answer: $20m$

SP11. Three vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ are shown. If $\vec{A}\cdot\vec{B} = -\vec{A}\cdot\vec{C}$ and $|\vec{B}| = |\vec{C}|$. **Find the angle (θ) between $\vec{A}$ and $\vec{B}$. [*Hint: cos* $\boldsymbol{\theta = -cos(180 - \theta)}$]**

$$\vec{A}\cdot\vec{B} = -\vec{A}\cdot\vec{C}$$
$$|A||B|\ cos\ \theta = -|A||C|\ cos\ (\theta + 20)$$
$$cos\theta = -cos\ (\theta + 20)$$
$$\theta = 80^\circ$$



Answer : 80°

Part III: Long Problems

LP1. A bird flies in the xy-plane with constant acceleration. The bird's velocity vector is given by $\vec{v} = (2.4 - 1.6t)\hat{\imath} + (4t)\hat{\jmath}$. At $t = 0$, **the bird is at the origin**.

a. Calculate the bird's acceleration vector (in m/s^2).

$$a = \frac{dv}{dt} = -1.6\,\hat{\imath} + 4\hat{\jmath}\ \text{m/s}^2$$

Answer: $-1.6\,\hat{\imath} + 4\hat{\jmath}\ \text{m/s}^2$

b. Calculate the position vector of the bird as a function of time.

$$\vec{r} = \vec{r}_i + \vec{v}_i\, t + \frac{1}{2}\,\vec{a}t^2$$

$$= 0 + 2.4\ \hat{\imath} + \frac{1}{2}(-1.6\hat{\imath} + 4\hat{\jmath})t^2$$

$$= (2.4\ - 0.8t^2)\hat{\imath} + 2t^2\hat{\jmath}\ m$$

Answer: $(2.4\,t - 0.8t^2)\hat{\imath} + 2t^2\hat{\jmath}\ m$

c. What is the bird's altitude (y-coordinate) as it flies over x=0 for the first time after t=0?

$$x = 0 \quad \Longrightarrow \quad 2.4\ t - 0.8\,t^2 = 0 \quad \Longrightarrow \quad t = 3$$

$$y(3) = 2(3)^2 = 18\ m$$

Answer: $18\ m$

LP2. Car A is staying at rest at the line of a traffic light. When it turns green, car A starts to move from rest with constant acceleration of 2 m/s^2. At the same instant car B crosses the same line and is moving with constant velocity of 4 m/s. The two cars cover the same distance of 36m.

a) Which car will cover the 36 m first?

Car A

$$\Delta x = \frac{1}{2}at^2 \Longrightarrow 36 = t^2 \ \therefore\ t = 6s$$

Car B

$$\Delta x = vt$$

$$t = \frac{\Delta x}{4} = \frac{36}{4} = 9s$$

Answer: Car A

b) What is the distance between the two cars at t = 5s?

$$\Delta x_A = \frac{1}{2}\,at^2 = 25m$$

$$\Delta x_B = vt = 20m$$

$\therefore$ the distance between them is 5m.

Answer: 5m