Kuwait University

Physics Department
Physics 101

First Midterm Exam
Second Semester
Saturday, March 14, 2015
1:30 – 3:30 p.m.

Student's Name: ……..……..……..……

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Prof. Fikry El-Akkad	Dr. Yacob Makdisi
Dr. Hasan Raafat	Dr. Abdul Khaleq
Dr. Ahmed Al-Jassar	Dr. Abdul Mohsen
Dr. Hala Al- Jassar	Dr. Nasser Demir
Dr. Tareq Alrefai	Dr. Belal Salameh

Grades: **For Instructors use only**

#	Q1	Q2	Q3	Q4	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	2	2	20

Important:

1. Answer all questions and problems.
2. Full mark = 20 points.
   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**.

GOOD LUCK

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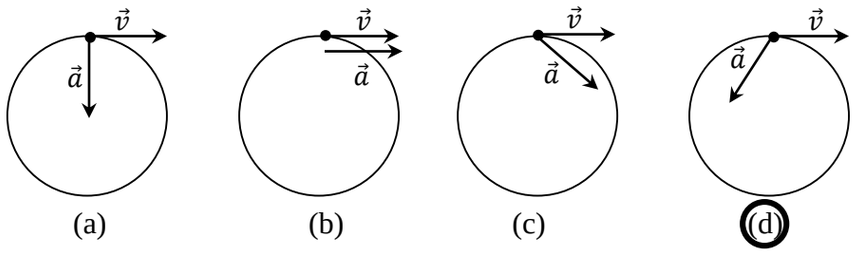
Part I: Questions (Choose the correct answer, one point each)

Q1. Which of the following figures properly represents the acceleration and velocity vectors for a particle rotating in **nonuniform circular motion with decreasing speed**?



Q2. If the acceleration of a particle is in the negative x direction, **which of the following must be true**?

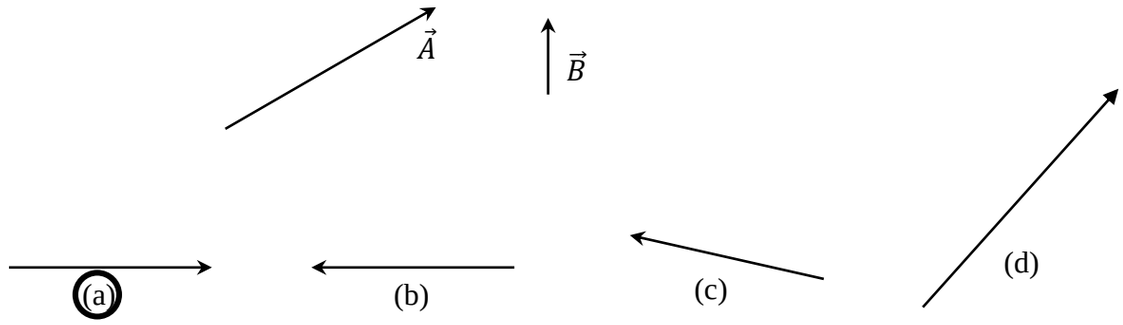
a. Its speed must be decreasing.

b. Its velocity must also be in the negative x direction.

c. Its velocity must be constant.

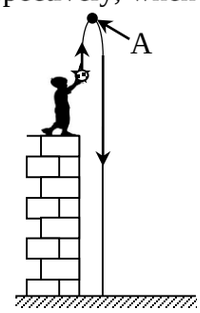
d. None of the above.

Q3. Given the two vectors $\vec{A}$ and $\vec{B}$ shown below, **choose the vector corresponding to $\vec{A}-2\vec{B}$**.



Q4. A ball is thrown vertically upward from the top of a building, as shown in the figure. Which of the following represents the signs of the **displacement, velocity, and acceleration,** respectively, when the ball reaches point A (the highest point in its motion.)

Take the upward direction as positive.



a. (+,+,+)

b. (+,0,–)

c. (+,–,–)

d. (+,0,0)

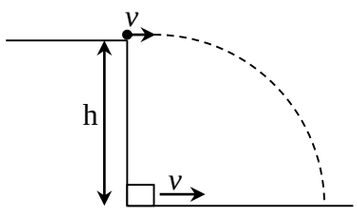
Q5. A stone is thrown in **the horizontal direction** with a **speed *v*** from a cliff of height h, as shown in the figure. At the same instant, a brick is kicked **horizontally** at the ground level and is given the **same initial speed *v*** which remains constant during its path. **Which of the following is true**?

a. The stone will strike the brick.

b. The stone will hit the ground in front of the brick.

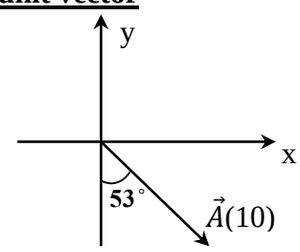
c. The stone will hit the ground behind the brick.

d. There is not enough information given to answer the question.



Part II: Short Problems (1 mark each)

SP1. Write down an expression for the vector $\vec{A}$ (where A = 10), shown in the figure, **in unit vector notation.**



$\vec{A} = 10\sin 53°\,\hat{\imath} - 10\cos 53°\,\hat{\jmath}$

$\vec{A} = 8\,\hat{\imath} - 6\hat{\jmath}$

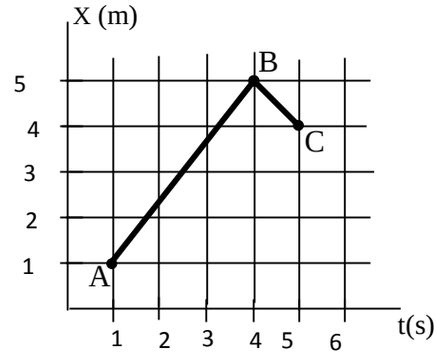
OR

$\vec{A} = 10\cos 323\,\hat{\imath} + 10\sin 323\,\hat{\jmath}$

$\vec{A} = 8\,\hat{\imath} - 6\hat{\jmath}$

Ans: $\vec{A} = 8\,\hat{\imath} - 6\hat{\imath}$

SP2. A graph of position versus time is shown for an object moving along the x-axis. Find the **average velocity (in m/s)** between points A and C.

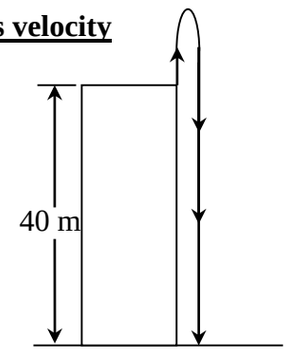


$V_{av} = \frac{\Delta x}{\Delta t} = \frac{4-1}{5-1} = \frac{3}{4} m/s$

$V_{av} = 0.75 m/s$

Ans: $V_{av} = 0.75 m/s$

SP3. A stone is thrown vertically upward from the roof of a building 40 m high. **Find its velocity (in m/s) at the moment it hits the ground** if the time of flight is 4 seconds.



$\Delta y = V_{fy}\Delta t + \frac{1}{2} g\Delta t^2$

$-40 = 4V_{fy} + 5(4)^2$

$4V_{fy} = -120$

$V_{fy} = -30\ m/s$

OR

$\Delta y = V_{oy}\Delta t - \frac{1}{2} g\Delta t^2$

$-40 = 4V_{oy} - 5(4)^2$

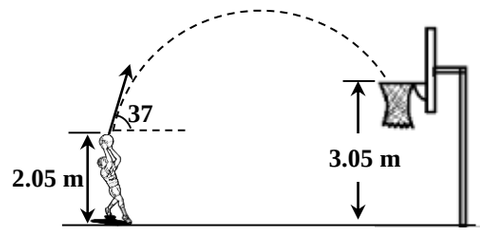
$4V_{oy} = 40 \Rightarrow V_{oy} = 10\ m/s$

$V_{fy} = V_{oy} - g\Delta t$

$V_{fy} = 10 - 10(4) = -30\ m/s$

Ans: $V = -30\ m/s$

SP4. A basketball player throws a ball with a speed v_o from a height of 2.05 m above the ground at an angle of 37° with the horizontal. The ball falls into a 3.05 m high basket after 2.00 seconds. **Find the initial speed v_o (in m/s) of the ball**.



$\Delta y = (V_o \sin\theta)\Delta t - \frac{1}{2} g\Delta t^2$

$3.05 - 2.05 = (V_o \sin 37°)(2) - 5(2)^2$

$1 = 1.2\,V_o - 20$

$21 = 1.2\,V_o$

$V_o = 17.5\ m/s$

Ans: $V_o = 17.5\ m/s$

SP5. **What are the two possible angles** at which a cannon must be oriented to hit a target at the same level and 80 m faraway if the shell is fired with speed of 40 m/s?

$$R = \frac{V_o^2 \sin 2\theta}{g} \quad \Rightarrow \theta = \frac{1}{2}\, sin^{-1}\left(\frac{Rg}{V_o^2}\right) = \frac{1}{2}\, sin^{-1}\left(\frac{80(10)}{40^2}\right)$$

$$\theta = 15° \;\Rightarrow\; \theta_2 = 90° - 15° = 75°$$

Ans: $\theta = \{15°, 75°\}$

SP6. An object moving with uniform acceleration has a velocity of **12.0 m/s** in the positive x direction when its x coordinate is **8.0 m**. If its x-coordinate is **–6.0 m** after **2.0 s**, **what is its acceleration (in m/s^2)?**

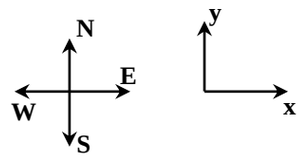
$$\Delta x = V_o \Delta t + \frac{1}{2} a\, \Delta t^2$$

$$-6 - 8 = 2(12) + \frac{1}{2} a (2)^2$$

$$2a = -38 \;\Rightarrow\; a = -19\, m/s^2$$

Ans: $a = -19\, m/s^2$

SP7. Ahmed walks 70 m west then 100 m at 30 degrees north of east. **Find Ahmed's resultant displacement (in m), in unit vector notation.**

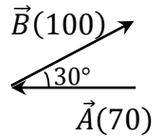


$\vec{A} = (-70\vec{\imath})m$

$\vec{B} = (100\cos 30\,\vec{\imath} + 100 \sin 30\,\vec{\jmath})m$

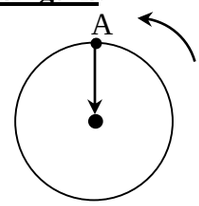
$= (86.6\,\vec{\imath} + 50\,\vec{\jmath})m$

$\vec{R} = (16.6\,\vec{\imath} + 50\,\vec{\jmath})m$



Ans: $(16.6\,\vec{\imath} + 50\,\vec{\jmath})m$

SP8. A wheel **3.0 m in diameter** rotates at a constant rate of **120 rev/min**. **Find the magnitude of the acceleration (in m/s^2) at point A** on the wheel's rim and **sketch its direction in the figure**.



$\omega = 120\,\frac{rev}{min} \Rightarrow f = \frac{120}{60} = 2\, rev/s$

$a_r = 4\pi^2 R f^2 = 4\pi^2 (1.5)(2)^2 = 236.9\, m/s^2$

OR

$V = \frac{2\pi R}{T}$

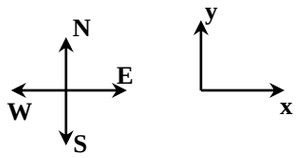
$= \frac{2(\pi)(1.5)}{1/2}$

$= 18.8\, m/s$

$a = \frac{v^2}{R} = 236.9\ m/s^2$

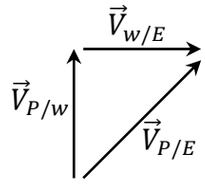
Ans: $236.9\, m/s^2$

SP9. The pilot of an airplane notes that the direction of the airplane relative to the wind is north. The airplane's speed relative to the wind is 210 km/h. The wind's velocity is 30 km/h due east. **Sketch the velocity diagram and find the velocity of the airplane (in km/h) relative to the ground (in unit vector notation).**



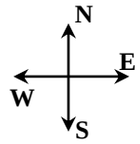
$$\vec{V}_{P/E} = \vec{V}_{P/w} + \vec{V}_{w/E}$$

$$\vec{V}_{P/E} = 210\hat{j} + 30\hat{\imath}\ km/h$$



Ans: $\vec{V}_{P/E} = 210\hat{j} + 30\hat{\imath}\ km/h$

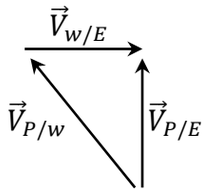
SP10. Suppose that in SP 9, the pilot wants the airplane to travel directly due north with respect to the ground. **Sketch the velocity vector diagram and determine the heading angle (with respect to north) to accomplish this**.



$$\sin\theta = \frac{|\vec{V}_{w/e}|}{|\vec{V}_{p/e}|} = \frac{30}{210} = \frac{1}{7}$$

$$\theta = sin^{-1}\left(\frac{1}{7}\right)$$

$$\theta = 8.2°\ (W\ of\ N)$$



Ans: $\theta = 8.2°\ (W\ of\ N)$

SP11. A car moves from point A to point B with a constant speed of 12 m/s. It returns back to point A with a constant speed of 8 m/s. **Find the average speed (in m/s) for the whole trip.**

$$\vec{S} = \frac{2d}{\frac{d}{12}+\frac{d}{8}}$$

$$\vec{S} = \frac{2}{\frac{1}{12}+\frac{1}{8}} = \frac{2(96)}{12+8} = 9.6\ m/s$$

Ans: $\vec{S} = 9.6\ m/s$

Part III: Long Problems (2 marks each)

LP1. A particle moves along the x axis, with its position given by $x=5t-t^2$, where t is in seconds and x is in meters.

(a) Determine the average velocity (in m/s) between t=0 and t=2 seconds.

(b) Find the time (in s) at which the particle changes its direction of motion.

a. $x_1 = 0 \quad x_2 = 5(2) - 2^2 = 6\ m \quad \bar{V} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} \Rightarrow \quad \bar{V} = \frac{6-0}{2-0} = 3\ m/s$

b. $V = 0$

$V = \frac{dx}{dt} = 5 - 2t$ $\Big\}$ $5 - 2t = 0 \Rightarrow t = 2.5\ s$

Ans: $V = 3\ m/s$

Ans: $t = 2.5\ s$

LP2. Starting with initial velocity $\vec{v}_o = 5\,\hat{i} + 12\,\hat{j}\ m/s$ a particle moves with acceleration $\vec{a} = -4\hat{j}\ m/s^2$. **Find the displacement (in m) of the particle when it reaches its maximum y coordinate (in unit vector notation)**.

$V_y = 0\ at \max\ y - coordinate$

$V_y = V_{0y} + a_y \Delta t \Rightarrow 0 = 12 - 4t \ \Rightarrow \ t = 3s$

$\Delta x = V_{ox}\Delta t + \frac{1}{2}\, a_x \Delta t^2$

$\Delta x = 5(3) = 15m$

$\Delta y = V_{oy} t + \frac{1}{2}\, a_y\, \Delta t^2$

$= 12(3) + \frac{1}{2}\,(-4)\,(3)^2$

$= 36 - 18 = 18\ m$

$\Delta \vec{r} = 15\,\vec{\imath} + 18\,\vec{\jmath}$

Ans: $\Delta \vec{r} = 15\,\vec{\imath} + 18\,\vec{\jmath}$