Kuwait University Physics Department

Physics 101

Fall Semester
First Midterm Exam
Saturday, January 9, 2021
9:00 am – 11:00 am

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

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Dr. Ahmed Al-Jassar
Dr. Hala Al-Jassar
Dr. Fatema Al Dosari
Dr. Nasser Demir
Dr. Tareq Al Refai
Dr. Belal Salameh
Dr. Abdel Khaleq

For Instructors use only

#	Q1	Q2	Q3	Q4	Q5	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	LP1	LP2	LP3	Total
Pts	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	**40**

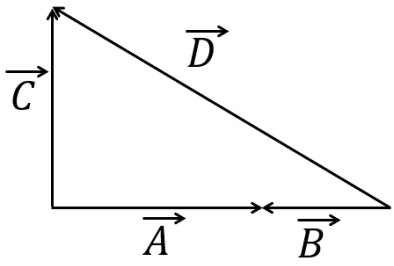
Important:

1. Answer all questions and problems.
2. Full mark = 40 points as arranged in the above table.
   i) 5 **Q**uestions
   ii) 9 **S**hort **P**roblems
   iii) 3 **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. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Questions (Choose the correct answer, 2 points each)

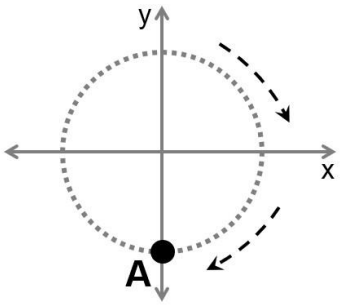
Q1. In the shown figure, **the vector $\vec{A}$ is equal to**



(*) $\vec{A} = \vec{B} + \vec{C} - \vec{D}$ * $\vec{A} = -\vec{B} + \vec{C} - \vec{D}$

* $\vec{A} = \vec{B} - \vec{C} + \vec{D}$ * $\vec{A} = \vec{C} - \vec{B} - \vec{D}$

Q2. A particle is rotating uniformly clockwise in a horizontal circle as shown in the figure. The **velocity** and the **acceleration** of the particle **<u>at point A</u>** can be described as:



* $\vec{v} = +3\,\hat{\imath}\ m/s,\ \vec{a} = -2\,\hat{\jmath}\ m/s^2$ (*) $\vec{v} = -3\,\hat{\imath}\ m/s,\ \vec{a} = +2\,\hat{\jmath}\ m/s^2$

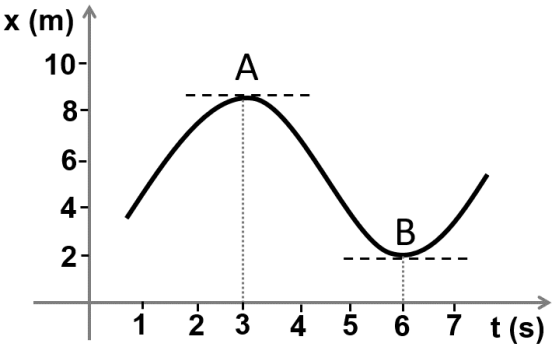
* $\vec{v} = +3\,\hat{\imath}\ m/s,\ \vec{a} = +2\,\hat{\jmath}\ m/s^2$ * $\vec{v} = -3\,\hat{\imath}\,m/s,\ \vec{a} = -2\,\hat{\jmath}\ m/s^2$

Q3. If the **speed** of a freely falling object is **increasing** as a function of time, then **its velocity and acceleration, respectively are:**

* negative and zero * negative and positive * positive and negative (*) negative and negative

---

Q4. The **position time** graph of an object traveling along the x-axis is shown. The **<u>average acceleration</u>** between $t = 3s$ (point A) and $t = 6s$ (point B) is:



* positive * negative

(*) zero * can't be determined

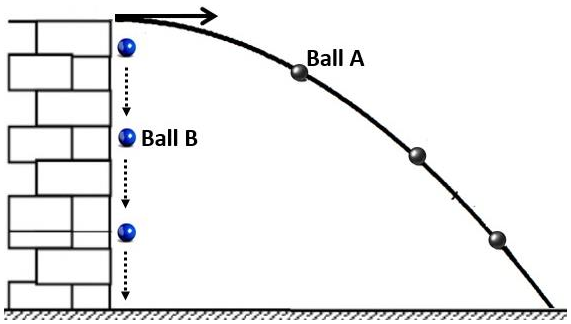
Q5. <u>Ball A</u> is thrown horizontally (with a nonzero initial speed) from the top of a building. At the same instant, **<u>ball B</u> is dropped vertically (from rest)**. Neglect air resistance. The relations between **the speeds of the balls (v_{Af} and v_{Bf}) and** the **times of fall (t_A and t_B) as they hit the ground are**:

(*) $t_A = t_B\ and\ v_{Af} > v_{Bf}$

* $t_A > t_B\ and\ v_{Af} = v_{Bf}$

* $t_A = t_B\ and\ v_{Af} = v_{Bf}$

* $t_A > t_B\ and\ v_{Af} > v_{Bf}$



Part II: Short Problems (2 points each)

SP1. If $\vec{A} = 2\hat{\imath} + 3\hat{\jmath} - 3\hat{k}$, $\vec{B} = -\hat{\imath} - \hat{\jmath} + 5\hat{k}$, $\vec{C} = \vec{A} + \vec{B}$. **Find the angle between the vector $\vec{C}$ and the positive z-axis**.

$\vec{C} = \hat{\imath} + 2\hat{\jmath} + 2\hat{k}$

$\gamma = cos^{-1}(\frac{C_z}{|\vec{C}|})$

$\gamma = cos^{-1}\left(\frac{2}{3}\right) = 48.2°$

SP2. A bird starts flying with an initial velocity $\vec{v} = 5\hat{\imath} - 6\hat{\jmath} + 4\hat{k}$, 10 s later the bird's velocity is $\vec{v} = 10\hat{\imath} - 6\hat{\jmath} - 8\hat{k}$. All velocities are in m/s. **Find the average acceleration of the bird during this 10 s interval in unit vector notation.**

$$\vec{a}_{av} = \frac{\vec{v}_f - \vec{v}_o}{t} = \frac{5\hat{\imath} - 12\hat{k}}{10}$$

$$= \left(0.5\hat{\imath} - 1.2\hat{k}\right) m/s^2$$

SP3. Given $\vec{A} = 3\hat{\imath} + 5\hat{\jmath}$, $\vec{B} = -4\hat{k}$, $\vec{C} = 2(\vec{A} \times \vec{B})$. **Find the vector $\vec{C}$ in unit vector notation**.

$\vec{A} \times \vec{B} = -20\hat{\imath} + 12\hat{\jmath}$

$\vec{C} = 2(-20\hat{\imath} + 12\hat{\jmath}) \ = -40\hat{\imath} + 24\hat{\jmath}$

SP4. The position of an object that moves along the x-axis is given by $x(t) = 32t - t^4$, where t is in s and x is in m. **Find the position of the object when it stops momentarily.**

$v(t) = \frac{dx}{dt} = 32 - 4t^3 = 0$

$t = \sqrt[3]{8} = 2\ s$

$x(2\ s) = 32(2) - (2)^4 = 48\ m$

SP5. A car starts from **rest** at the first traffic light and accelerates at 3 m/s^2 for 10 s to reach a speed of 30 m/s. After that it slows down at a rate of 2 m/s^2 **to stop** at the next traffic light. **Find the distance between the two traffic lights.**

$\Delta x_1 = v_0 t + \frac{1}{2}at^2 = \frac{1}{2}(3)(10)^2 = 150\ m$

$\Delta x_2 = \frac{v_f^2 - v_0^2}{2a} = \frac{0 - 900}{-4} = 225\ m$

$\Delta x = 150 + 225 = 375m$

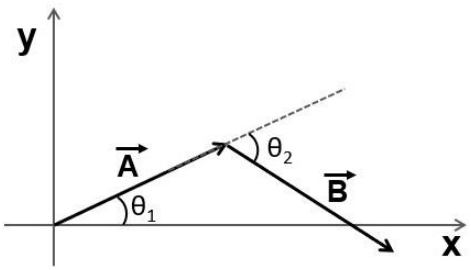
SP6. At $t = 0\ s$ **a ball** is thrown vertically upward from the ground with an initial speed of 20 m/s. After 2 s, **a stone** is thrown vertically upward from the ground with an initial speed of 25 m/s. **How long it will take before they pass each other?**

$y_b = y_s$

$20t - 5t^2 = 25(t-2) - 5(t-2)^2$

$t = 2.8\ s$

SP7. Vectors $\vec{A}$ and $\vec{B}$ have **equal magnitudes** of 6 m. The angle $\theta_1 = 30°$, while the angle $\theta_2 = 70°$. **Find the Vector $\vec{A} + \vec{B}$ in unit vector notation.**



$\vec{A} = 6\cos 30\,\hat{\imath} + 6\,sin30\hat{\jmath} = (5.2\hat{\imath} + 3\hat{\jmath})\ m$

$\vec{B} = 6\cos 40\,\hat{\imath} - 6\,sin40\hat{\jmath} = (4.6\hat{\imath} - 3.9\hat{\jmath})\ m$

$\vec{A} + \vec{B} = (9.8\,\hat{\imath} - 0.9\,\hat{\jmath})\ m$

SP8. A particle starts from **the origin** at $t = 0\ s$ with a velocity of $\vec{v}_o = 18\hat{\imath}\ m/s$ and moves with a constant acceleration of $\vec{a} = (-2\hat{\imath} + 4\hat{\jmath})\ m/s^2$. **Find the particle's velocity vector $\vec{v}$ when its velocity is perpendicular to its acceleration ($\vec{v}\,.\vec{a} = 0$).**

$\vec{v}_f = \vec{v}_o + \vec{a}t = (18 - 2t)\hat{\imath} + 4t\hat{\jmath}$

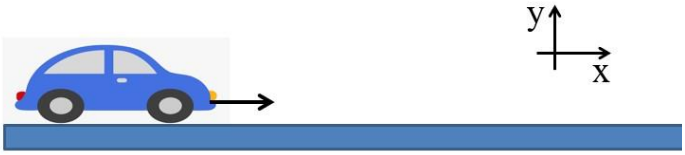
$\vec{v}\,.\vec{a} = 0 \implies -36 + 4t + 16t = 0 \implies t = 1.8\ s$

$\vec{v}(1.8\ s) = (14.4\,\hat{\imath} + 7.2\,\hat{\jmath})\ m/s$

SP9. A car travels to the right with a speed of 15 m/s. Rain is falling **vertically** relative to the ground with a speed of 4 m/s. **Find the velocity of the rain with respect to the car in unit vector notation.**

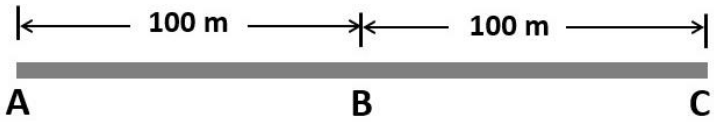
$\vec{v}_{r/c} = \vec{v}_{r/g} - \vec{v}_{c/g}$

$= (-4\,\hat{\jmath} - 15\,\hat{\imath})\ m/s$



Part III: Long Problems (4 points each)

LP1. A car starts from **rest** at point A and moves to the right with **constant acceleration**. It covers the first 100 m in 12 s (from A to B).



a) Find the car's acceleration.

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

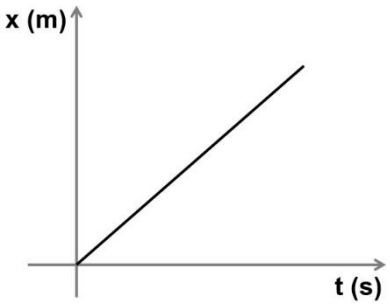
$$100 = 0 + \frac{1}{2} a_x (12)^2 \Rightarrow a_x = 1.39\ m/s^2$$

b) How long it will take to cover the next 100 m (from B to C).

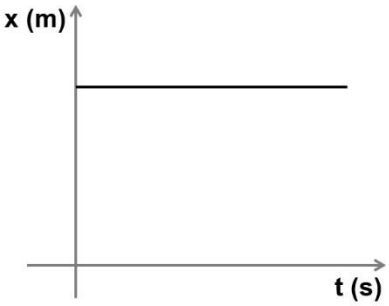
$$200 = 0 + \frac{1}{2}(1.39) t^2 \Rightarrow t = 16.97\ s$$

$$\Delta t = 4.97\ s$$

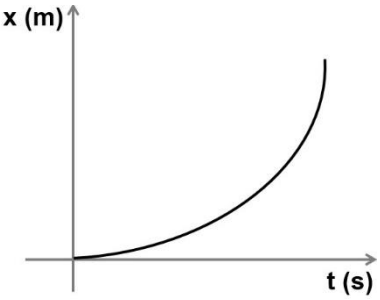
c) Which of the following three graphs represents the position of the car versus time?



*



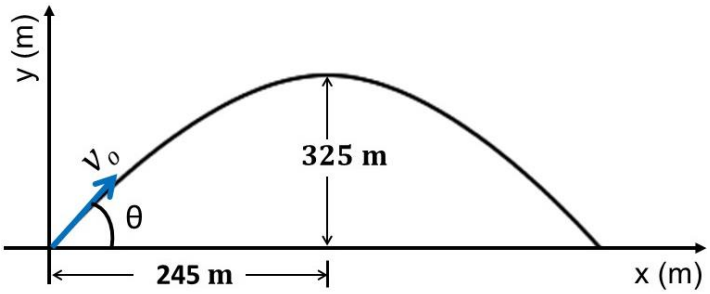
*



⊛

LP2. A projectile is fired from the ground level as shown in the figure.

a) What minimum vertical component of initial velocity (v_{y_o}) is needed to reach a maximum height of 325 m



$$v_y^2 = v_{y_o}^2 - 2g\Delta y$$

$$0 = v_{y_o}^2 - 2(10)(325)$$

$$v_{y_o} = 80.6\ m/s$$

b) What is the horizontal component of the initial velocity (v_{x_o}).

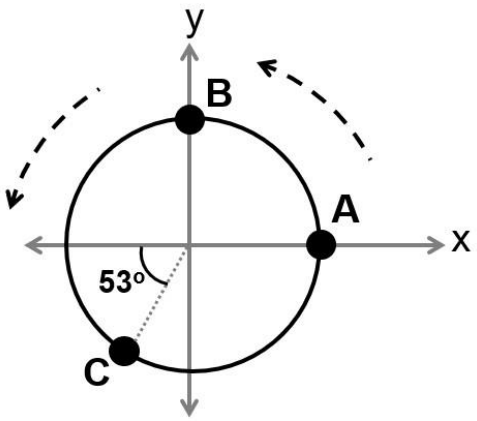
$$v_y = v_{y_o} - gt \Rightarrow t = \frac{80.6}{10} = 8.06\ s$$

$$v_{x_o} = \frac{\Delta x}{t} = \frac{245}{8.06} = 30.4\ m/s$$

LP3. A particle moves **uniformly** counterclockwise in a circule of radius ($R = 6\ m$) as shown in the figure. The particle rotates at 50 rpm.

a) Find the period of the particle's motion.

$$T = \frac{1}{50/60} = 1.2\ s$$



b) Find the average velocity of the particle between points A and B, in unit vector notation. <u>(consider the first revolution)</u>

$$\vec{v}_{av} = \frac{\vec{r}_B - \vec{r}_A}{\Delta t} = \frac{6\,\hat{j} - 6\hat{\imath}}{\frac{1}{4}(1.2)} = (-20\,\hat{\imath} + 20\hat{\jmath})\ m/s$$

c) Find the average speed between points B and C.

$$v = (50)\left(\frac{rev}{min}\right)\left(\frac{2\pi R\ (m)}{1\ rev}\right)\left(\frac{1\ (\text{min})}{60\ (s)}\right) = 31.4\ m/s$$

Or: $v = \frac{2\pi R}{T} = \frac{2\times 3.14\times 6}{1.2} = 31.4\ m/s$

Or: $360° \rightarrow 1.2\ s$ $360° \rightarrow 2\times\pi\times R = 37.68\ m$

From B to C: $143° \Rightarrow d_{B\rightarrow C} = 14.97\ m$ & $t_{B\rightarrow C} = 0.477\ s$

$$v = \frac{14.97}{0.477} = 31.4\ m/s$$