Kuwait University Physics Department

Physics 101

Spring Semester
First Midterm Exam
Saturday, February 22, 2020
9:00 am – 10:30 am

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

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Prof. Yacoub Makdisi	Dr. Tareq Al Refai
Dr. Ahmed Al-Jassar	Dr. Belal Salameh
Dr. Hala Al-Jassar	Dr. Abdel Khaleq
Dr. Nasser Demir	Dr. Fatma Douseri

For Instructors use only

Grades:

#	Q1	Q2	Q3	Q4	SP1	SP2	SP3	SP4	SP5	LP1	LP2	Total
Pts	1	1	1	1	2		2	2	2	3	3	20

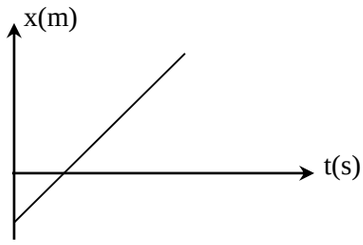
Important:

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

GOOD LUCK

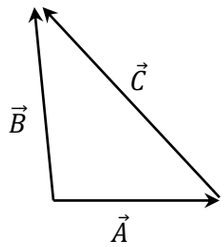
Part I: Questions (Choose the correct answer, one point each)

Q1. If the position of a particle moving along the x-axis as a function of time is shown in the figure, then the **speed** of the particle



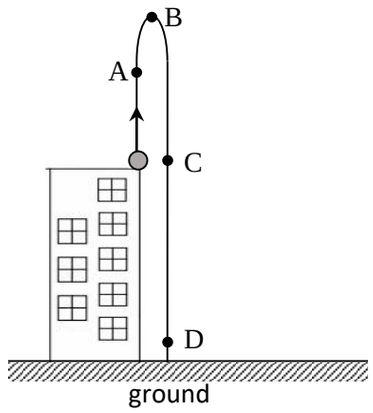
- Increases
- Decreases
- (*) Constant
- Decreases then increases

Q2. The vector $\vec{C}$ in the diagram is equal to



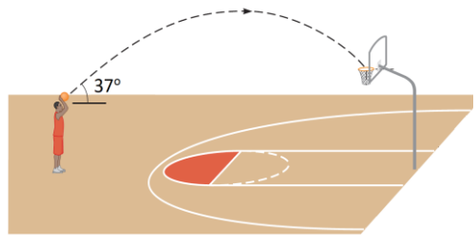
- $\vec{A} - \vec{B}$
- $\vec{A} + \vec{B}$
- (*) $\vec{B} - \vec{A}$
- $-(\vec{A} + \vec{B})$

Q3. A ball is thrown upward from the top of a building as shown. The ball's **displacement relative to the starting position is zero at point:**



- A
- B
- (*) C
- D

Q4. A basketball is projected at an angle of 37° above the horizontal with an initial speed of $v_0 = 6\ m/s$. Its **velocity at the <u>maximum height</u>** (in unit vector notation) is



- Zero
- (*) $4.8\,\hat{\imath}\ m/s$
- $3.6\,\hat{\imath}\ m/s$
- $(4.8\,\hat{\imath} + 3.6\,\hat{\jmath})\ m/s$

Part II: Short Problems (2 points each)

SP1. After an airplane takes off, it travels 6 km east, 3 km north, and 2 km up. **How far at this point (in km) is the airplane from the take off point**?

$$d = \sqrt{6^2 + 3^2 + 2^2} = 7\ km$$

Answer: $d = 7\ km$

SP2. A particle, at $x = -6\ m$, starts to move **from rest** along the x-axis with **constant acceleration**. Find its acceleration (in m/s^2) if the time required for the particle to reach $x = 8\ m$ is 2 sec.

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

$$14 = 0 + \frac{1}{2}a_x(2)^2$$

$$a_x = 7\ m/s^2$$

Answer: $a_x = 7\ m/s^2$

SP3. If $\vec{A} = 2\hat{\imath} + \hat{\jmath} + 2\hat{k}$

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

$\vec{C} = \vec{A} + \vec{B}$

What is the angle between $\vec{C}$ and the positive y-axis?

$\vec{c} = 0\hat{\imath} + 3\hat{\jmath} + 1\hat{k}$

$$\beta = cos^{-1}\left(\frac{c_y}{|\vec{c}|}\right) = cos^{-1}\left(\frac{3}{\sqrt{10}}\right) = 18.4°$$

$= 18.4°$

[**OR**]

$\vec{c} = 0\hat{\imath} + 3\hat{\jmath} + 1\hat{k}$

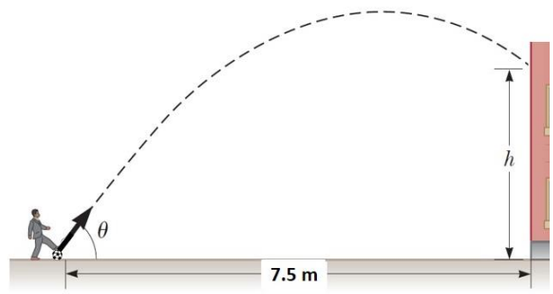
$$\beta = tan^{-1}\left(\frac{c_z}{c_y}\right) = tan^{-1}\left(\frac{1}{3}\right)$$

Answer: $\beta = 18.4°$

SP4. A boy kicks a ball from the ground level at an angle θ above the horizontal to a wall **7.5 m away** as shown in the figure. If the **initial speed of the ball is 14 m/s** and **it takes 2 s to reach the wall**, **at what height h (in m) does the ball strike the wall? Ignore air resistance.**

$$\Delta x = v_{xi}t = v_i \cos(\theta)\, t$$

$$\Rightarrow \theta = cos^{-1}\left(\frac{\Delta x}{v_i t}\right) = cos^{-1}\left(\frac{7.5}{14(2)}\right) = 74.5^o$$



$$\Delta y = v_i \sin(\theta)\, t - \frac{1}{2}gt^2 = 14\sin(74.5^o)\,(2) - 5(2)^2$$

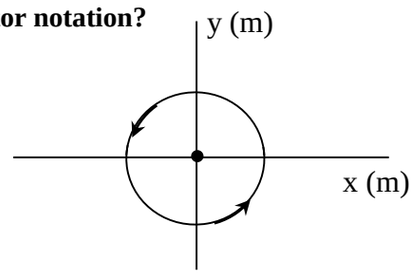
$$= 7\ m$$

Answer: $h = 7\ m$

SP5. A particle moves counterclockwise in a horizontal circle, of radius 2 m, centered on the origin. At a certain instant the velocity and acceleration of the particle are $\vec{V} = -6\hat{\jmath}\ m/s$ and $\vec{a} = (3\hat{\imath} + 4\hat{\jmath})\ m/s^2$ respectively.

a. What is the position vector $\vec{r}$ of the particle at this instant in unit vector notation?

$$\vec{r} = -2\hat{\imath}\ m$$



b. The speed of the particle at this instant is

* increasing or (*) decreasing or * constant

Answer: $\vec{r} = -2\hat{\imath}\ m$

Part III: Long Problems (3 points each)

LP1. Car A leaves city A towards city B with **a constant speed of 20 m/s**. At the same instant, car B leaves city B **from rest** towards city A with a **constant acceleration of 0.05 m/s^2**. **The two cars pass each other after 5 minutes**.

a) Find the distance (in m) between the two cities A and B.

$t = 5 \times 60 = 300\ s$

$\Delta x_{total} = \Delta x_A + \Delta x_B$

$= \left(v_{Ai}t + \frac{1}{2}a_A t^2\right) + \left(v_{Bi}t + \frac{1}{2}a_B t^2\right)$

$= (20(300) + 0) + (0 + \frac{1}{2}(0.05)(300)^2)$

$= 8250\ m$

Answer: $d = 8250\ m$

b) Find the speed (in m/s) of each car at the instant they pass each other.

$V_{A_f} = 20\ m/s$

$V_{B_f} = V_{B_i} + a_B t$

$= 0 + 0.05\ (300) = 15\ m/s$

Answer: $V_A = 20\ m/s$

$V_B = 15\ m/s$

c) How long (in s) will take car A to reach city B?

$\Delta x = 8250\ m$

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

$8250 = 20\ t\ + 0$

$t = \frac{8250}{20} = 412.5\ s$

Answer: $t = 412.5\ s$

LP2. A particle is moving in x-y plane, its position vector is given by

$\vec{r} = [(6 + 3t)\hat{\imath} + (5 + 2t - 2t^2)\hat{\jmath}]\ m$, where t is measured in seconds.

a) Find its position vector and velocity vector at t = 0 s (in unit vector notation).

$\vec{r}(t = 0\ s) = (6\hat{\imath} + 5\hat{\jmath})m$

$\vec{v}(t) = \frac{d\vec{r}(t)}{dt} = (3\hat{\imath} + (2 - 4t)\hat{\jmath})\ m/s$

$\vec{v}(t = 0\ s) = (3\hat{\imath} + 2\hat{\jmath})\ m/s$

Answer: $\vec{r}(t = 0\ s) = (6\hat{\imath} + 5\hat{\jmath})m$

Answer: $\vec{v}(t = 0\ s) = (3\hat{\imath} + 2\hat{\jmath})\ m/s$

b) Find the acceleration of the particle (in unit vector notation).

$\vec{a}(t) = \frac{d\vec{v}(t)}{dt} = 0\hat{\imath} - 4\hat{\jmath} = -4\hat{\jmath}\ m/s^2$

Answer: $\vec{a}(t) = -4\hat{\jmath}\ m/s^2$

c) How long (in s) will take the particle to reach the maximum y-coordinate?

y is maximum when $v_y = 0$

$\Longrightarrow 2 - 4t = 0 \qquad \Longrightarrow t = 0.5\ s$

Answer: $t = 0.5\ s$