Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Spring Semester
First Midterm Exam
Saturday, March 11, 2023
4:30 PM – 6:00 PM

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

Student's Number: … Solution…….. Section: ……

Choose your Instructor's Name:

Dr. Abdulmuhsen Ali
Dr. Tareq Alrefai
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Dr. Abdul Khaleq
Dr. Nasser Demir
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Dr. Bedoor Alkurtass

For Instructors use only

Grades:

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

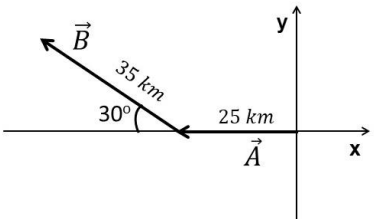
Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 20 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. Two displacement vectors are shown. **Find $\vec{A} - \vec{B}$ in unit vector notation.**



$\vec{A} = -25\,\hat{\imath}\ km$

$\vec{B} = (-35\cos 30^o\,\hat{\imath} + 35\sin 30^o\,\hat{\jmath})\ km = (-30.3\,\hat{\imath} + 17.5\,\hat{\jmath})km$

$\vec{A} - \vec{B} = -25\hat{\imath} - (-30.3\,\hat{\imath} + 17.5\,\hat{\jmath}) = (5.3\,\hat{\imath} - 17.5\,\hat{\jmath})\ km$

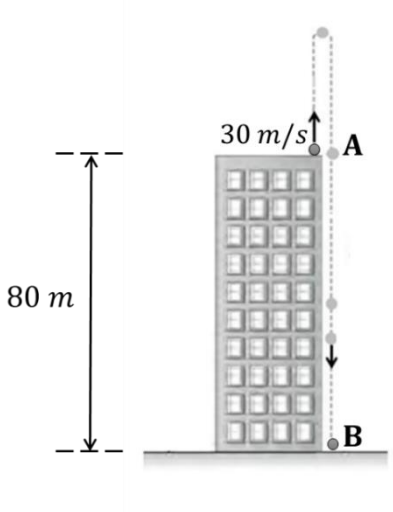
SP2. Consider the following vectors: $\vec{A} = 4\hat{\imath} + 2\hat{\jmath} + 3\hat{k}, \vec{B} = 6\hat{\imath} - 3\hat{\jmath} + 2\hat{k}, and\ \vec{C} = \vec{A} \times \vec{B}$. **Find the angle between $\vec{C}$ and the positive x-axis.**

$$\vec{C} = \vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 4 & 2 & 3 \\ 6 & -3 & 2 \end{vmatrix} = [(2)(2) - (3)(-3)]\,\hat{\imath} + [(3)(6) - (4)(2)]\,\hat{\jmath} + [(4)(-3) - (2)(6)]\,\hat{k}$$

$$= 13\,\hat{\imath} + 10\,\hat{\jmath} - 24\,\hat{k}$$

$$\alpha = cos^{-1}\left(\frac{C_x}{|\vec{C}|}\right) = cos^{-1}\left(\frac{13}{29.07}\right) = 63.4^o$$

SP3. A stone is thrown vertically upward from point A at the top of a building 80 m high, as shown. Its initial speed is 30 m/s. **Find the total time it takes to reach the ground (point B).**



$\Delta y = v_{yi}t - \frac{1}{2}gt^2$

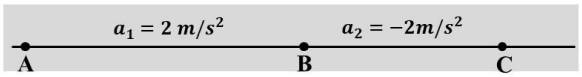
$-80 = 30t - 5t^2$

$t^2 - 6t - 16 = 0$

$(t - 8)(t + 2) = 0$

$t = 8\ s$

SP4. A particle starts **from rest** at point A and moves for 4 s with an acceleration of $+2\ m/s^2$ to reach point B. Then it moves from B to C in 3 s with acceleration of $-2\ m/s^2$. **What is the distance between A and C?**



$$\Delta x_{AB} = v_{x_A}\, t + \frac{1}{2} a_{x1} t^2 = 0 + \frac{1}{2}(2)(4)^2 = 16\ m$$

$$v_{x_B} = v_{x_A} + a_{x1} t = 0 + (2)(4) = 8\ m/s$$

$$\Delta x_{BC} = v_{x_B}\, t + \frac{1}{2} a_{x2} t^2 = 8(3) + \frac{1}{2}(-2)(3)^2 = 15\ m$$

$$\Delta x_{AC} = \Delta x_{AB} + \Delta x_{BC} = 16 + 15 = 31\ m$$

SP5. A particle is moving in the ***xy*-plane**. Its position vector as a function of time is given by $\vec{r} = (2 + 5t - t^2)\ \hat{\imath} + 4\ \hat{\jmath}$, where $\vec{r}$ is measured in meters and t in seconds. **Find the <u>average velocity</u> of the particle in unit vector notation in the interval from $t = 0\ s$ to $t = 3\ s$.**

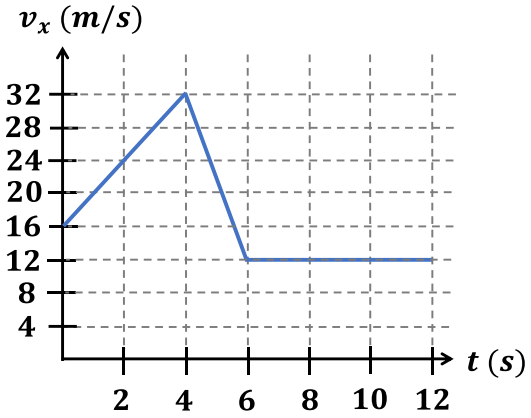
$$\Delta\vec{r} = \vec{r}_3 - \vec{r}_o = (8\,\hat{\imath} + 4\,\hat{\jmath}\,) - (2\hat{\imath} + 4\,\hat{\jmath}) = 6\,\hat{\imath}\ m$$

$$\vec{v}_{av} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r}_3 - \vec{r}_o}{\Delta t} = \frac{6\hat{\imath}}{3} = 2\,\hat{\imath}\ m/s$$

Part II: Long Problems (3 points each)

LP1. An object is moving along the x-axis. Its velocity changes with time as shown in the graph.

a) What is the initial velocity of the object ($at\ t = 0\ s$)?



from the graph

$v_{ox} = 16\ m/s$

b) Find the average acceleration between $t = 4\ s$ and $t = 6\ s$.

$$a_x = \frac{\Delta v}{\Delta t} = \frac{12 - 32}{6 - 4} = \frac{-20}{2} = -10\ m/s^2$$

c) Find the acceleration at $t = 8\ s$.

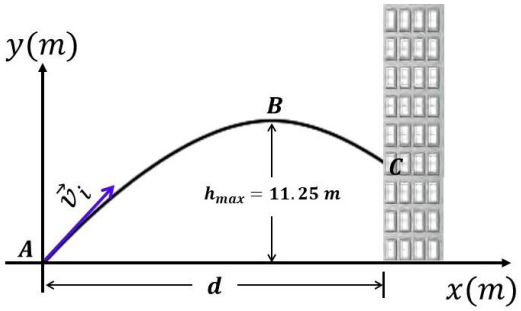
$a_x = 0$

d) Find the distance covered by the object in the interval from $t = 0\ s$ to $t = 4\ s$.

$$d = area = \frac{1}{2}(16\ m/s)(4\ s) + (16\ m/s)(4\ s) = 96\ m$$

LP2. A ball is projected from the ground level at point A and hits a building at point C after 2 s, as shown. Its speed at the maximum height (point B) is 12 m/s.

a) Find the initial velocity of the ball ($\vec{v}_i$) in unit vector notation.



from point A to point B

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

$0^2 = v_{y_i}^2 - 20(11.25) \Rightarrow v_{y_i} = 15\ m/s$

$v_{x_i} = v_{x_f} = 12\ m/s$

$\vec{v}_i = (12\hat{\imath} + 15\hat{\jmath})\ m/s$

b) Find the horizontal distance (d) between point A and point C.

$d = v_{x_i} t_{total} = 12(2) = 24\ m$

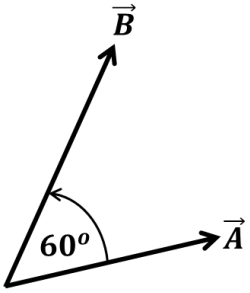
c) Find the height of point C.

from point A to point C

$\Delta y = v_{y_i} t - \frac{1}{2} g t^2 = 15(2) - (5)(2^2) = 10\ m$

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

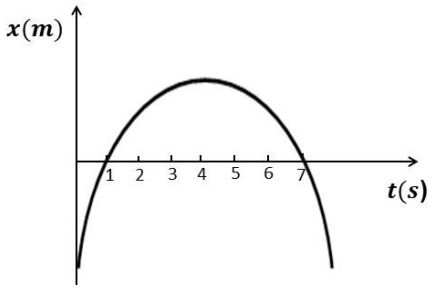
Q1. Two vectors $\vec{A}$ and $\vec{B}$ are shown. The magnitudes of the vectors are $|\vec{A}| = 3$ and $|\vec{B}| = 4$. The result of the dot product $\vec{A}.\vec{B}$ is:



(*) **6**

* **10.4**
* **$1.5\hat{i} + 2.6\hat{j}$**
* **$3\hat{i} + 9.1\hat{j}$**

Q2. The figure describes the position of an object moving along x-axis as a function of time. **One of the following statements is correct at $t = 1\ s$.**



* **The velocity of the object is zero.**
* **The acceleration of the object is zero.**
(*) **The velocity of the object is positive.**
* **The acceleration of the object is positive.**

Q3. An animal is running along the x-axis with a speed of 16 m/s and **slowing down** at a constant rate of 3 m/s^2. **The velocity and acceleration of the animal, respectively, are:**

* $(v_x = +16\ m/s, a_x = +3\ m/s^2)$
(*) $(v_x = +16\ m/s, a_x = -3\ m/s^2)$
* $(v_x = -16\ m/s, a_x = -3\ m/s^2)$
* $(v_x = -16\ m/s, a_x = zero)$

Q4. Three balls of different masses are thrown **horizontally** from the same height with different initial speeds $(v_{1_i} < v_{2_i} < v_{3_i})$, as shown. **The relation between the times the balls take to hit the ground is:**

* **$t_1 < t_2 < t_3$**
* **$t_1 > t_2 > t_3$**
(*) **$t_1 = t_2 = t_3$**