Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Fall Semester
First Midterm Exam
Saturday, October 29, 2022
9:00 AM – 10:30 AM

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

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

Choose your Instructor's Name:

Dr. Hala Al- Jassar	Dr. Abdul Khaleq
Dr. Tareq Alrefai	Dr. Nasser Demir
Dr. Fatema Al Dosari	Dr. Ruqayyah Askar
Dr. Belal Salameh	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

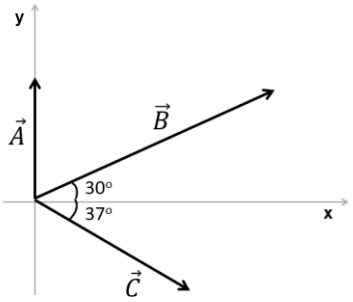
Important:

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. Three displacement vectors are shown, where $|\vec{A}| = 20\,m$, $|\vec{B}| = 40\,m$, and $|\vec{C}| = 30\,m$. **Find the resultant displacement in unit vector notation.**



$\vec{A} = +20\,\hat{\jmath}\,m$

$\vec{B} = (+40\cos 30^o\,\hat{\imath} + 40\sin 30\,\hat{\jmath})m = (+34.6\,\hat{\imath} + 20\,\hat{\jmath})m$

$\vec{C} = (+30\cos 37^o\,\hat{\imath} - 30\sin 37\,\hat{\jmath})\,m = (+24\,\hat{\imath} - 18\,\hat{\jmath})m$

$\vec{R} = \vec{A} + \vec{B} + \vec{C} = (34.6 + 24)\hat{\imath} + (20 + 20 - 18)\hat{\jmath} = (58\hat{\imath} + 22\hat{\jmath})\,m$

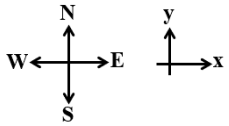
SP2. Consider the following vectors: $\vec{A} = 5\hat{\imath} + 4\hat{\jmath}$ and $\vec{B} = 8\hat{\imath} - 6\hat{\jmath}$. **Find the vector $\vec{C}$, where $\vec{C} = \frac{\vec{B}\times\vec{A}}{\vec{B}\cdot\vec{A}}$**

$$\vec{B}\times\vec{A} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 8 & -6 & 0 \\ 5 & 4 & 0 \end{vmatrix} = [(8)(4) - (-6)(5)]\,\hat{k} = 62\,\hat{k}$$

$$\vec{B}\cdot\vec{A} = (5)(8) + (4)(-6) = 16$$

$$\vec{C} = \frac{\vec{B}\times\vec{A}}{\vec{B}\cdot\vec{A}} = 3.9\,\hat{k}$$

SP3. A particle has an initial velocity of $4\,m/s$ **toward the east** and a final velocity of $8\,m/s$ **toward the north**. The particle was subject to a constant acceleration for $0.8\,s$. **Find the particle's acceleration in unit vector notation**.



$\vec{v}_i = 4\,\hat{\imath}\,m/s$

$\vec{v}_f = 8\,\hat{\jmath}\,m/s$

$\vec{v}_f = \vec{v}_i + \vec{a}t$

$$\Rightarrow \vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t} = \frac{8\,\hat{\jmath} - 4\,\hat{\imath}}{0.8} = 10\,\hat{\jmath} - 5\,\hat{\imath} = (-5\,\hat{\imath} + 10\,\hat{\jmath})\,m/s^2$$

SP4. The position of a particle moving along the $x-axis$ is given by $x(t)=2t^3-12t^2+18$, where x is in (m) and t is in (s). **What is the value of x when the particle's acceleration is zero?**

$$v_x(t)=\frac{dx}{dt}=(6t^2-24t)\ m/s$$

$$a_x(t)=\frac{dv_x}{dt}=(12t-24)\ m/s^2$$

$$12t-24=0\Rightarrow t=2s$$

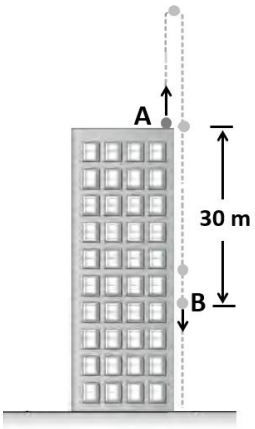
$$x(t=2s)=2(2^3)-12(2^2)+18=-14\,m$$

SP5. A ball is thrown vertically upward from point A at the top of a building, as shown. It reaches point B, which is 30 m below point A, in a time of 5 s. **Find the initial speed of the ball (at point A).**

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

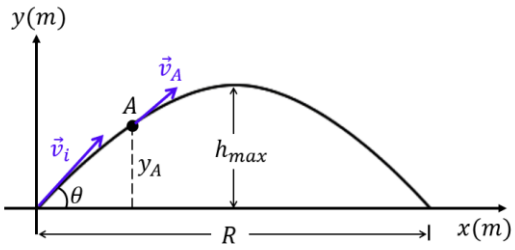
$$-30=v_{y_i}(5)-5(5^2)$$

$$\Rightarrow v_{y_i}=19\ m/s$$



Part II: Long Problems (3 points each)

LP1. A projectile is fired from the ground level, as shown. When the projectile is at a height of $y_A = 4\ m$ (point A), its velocity is $\vec{v}_A = (6\,\hat{\imath} + 8\,\hat{\jmath})\ m/s$.



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

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

$8^2 = v_{y_i}^2 - 20(4) \Rightarrow v_{y_i} = 12\ m/s$

$v_{x_i} = v_{x_f} = 6\ m/s$

$\vec{v}_i = (6i + 12j)\ m/s$

b) Find the projectile's maximum height (h_{max}).

$$h_{max} = \frac{v_{y_i}^2}{2g} = \frac{12^2}{20} = 7.2\ m$$

c) Find the horizontal range (R) of the projectile.

$$t_{total} = \frac{2v_{y_i}}{g} = \frac{2(12)}{10} = 2.4\ s$$

$R = v_{x_i} t_{total} = 6(2.4) = 14.4\ m$

LP2 A **truck** travelling at **a constant speed** of 18 m/s passes **a police car** that is initially **at rest**. After 2s of that instant, the police car starts to follow the truck with a constant acceleration of 4 m/s^2.

a) **How long does it take the police car to reach the truck?**

$$\Delta x(\text{police car}) = \Delta x(\text{truck})$$

$$v_{x_i}t + \frac{1}{2}a_x t^2 = v_{x_i}(t+2) + \frac{1}{2}a_x(t+2)^2$$

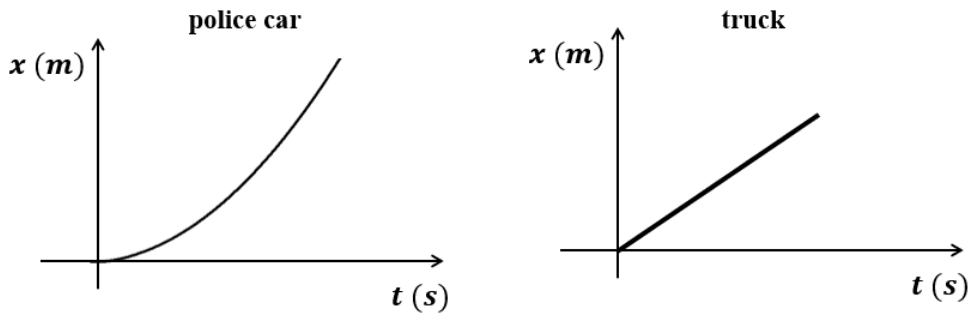
$$0 + \frac{1}{2}(4)t^2 = 18(t+2) + 0$$

$$t^2 - 9t - 18 = 0 \Rightarrow t = 10.7\ s$$

b) **How fast is the police car travelling when it reaches the truck?**

$$v_{x_f} = v_{x_i} + a_x t = 0 + 4(10.7) = 42.8\ m/s$$

c) **Plot two graphs of (x versus t), one graph for the truck and one graph for the police car.**



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

Q1. In which of the following cases does a car have **a negative velocity** and **a positive acceleration**?

A car that is traveling in the

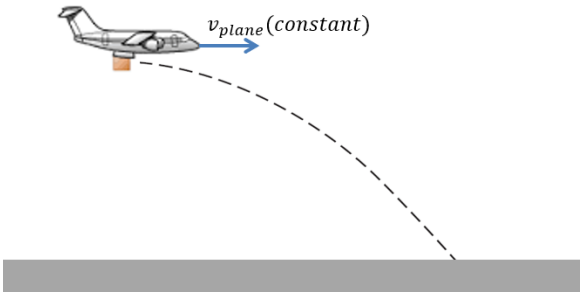
* $-x$ direction and speeding up.
* $-x$ direction and slowing down. (circled)
* $+x$ direction and speeding up.
* $+x$ direction and slowing down.

Q2. The value of $\hat{k}.(\hat{k} \times \hat{\imath})$ is:

* $+1$
* -1
* $\sqrt{3}$
* $zero$ (circled)

Q3. A pilot releases a package from a plane **flying horizontally at a constant speed**. Neglecting air resistance, when the package hits the ground the horizontal location of the plane will be

* behind the package.
* directly above the package. (circled)
* in front of the package.
* cannot be determined.



Q4. Ball A is released **from rest** from the top of a building. **One second later**, ball B is released **from rest** from the **same building**. As time progresses, **the difference in their velocities**. (Assume no air resistance)

* increases
* remains constant (circled)
* decreases
* cannot be determined