Kuwait University Physics Department

Physics 101

Summer Semester
Midterm Exam
Saturday, October 24, 2020
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. Fatma Al Dousari

Dr. Belal Salameh

For Instructor use only

Grades:

#	Q1	Q2	Q3	Q4	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Total
Pts	1.5	1.5	1.5	1.5	2	2	2	2	2	2	2	2	2	2	2	2	30

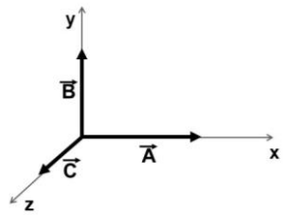
Important:

1. Answer all questions and problems.
2. Each has 30 points as arranged in the above table.
   i) 4 Questions
   ii) 12 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. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Questions (Choose the correct answer, 1.5 points each):

Q1. $\vec{A}, \vec{B}$ and $\vec{C}$ are three vectors directed along the x, y and z axes respectively, as shown. If $|\vec{A}| = 4, |\vec{B}| = 3$ and $|\vec{C}| = 2$ then $\vec{A} \cdot (2\vec{B} \times \vec{C})$ equal



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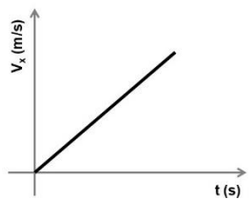
Q2. A particle is moving along the positive x-axis **with constant <u>velocity</u>**. The graph which represents this motion is:



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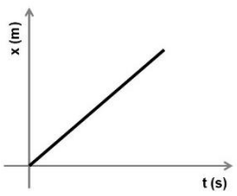

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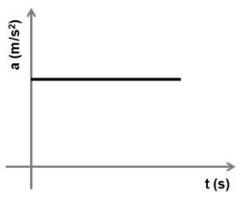

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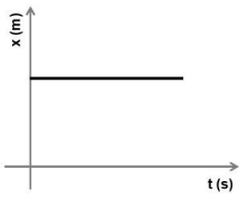

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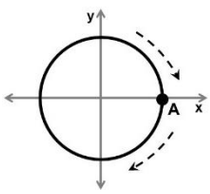
Q3. A particle is rotating **clockwise in a horizontal circle**. If the velocity and acceleration of this particle at point A are $\mathbf{3\,\hat{\jmath}\ m/s}$ **and** $\mathbf{1\,\hat{\imath}\ m/s^2}$ respectively, then the figure in which point A satisfies this condition is:



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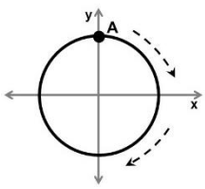

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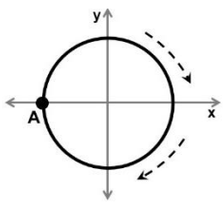

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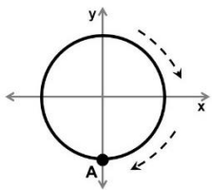

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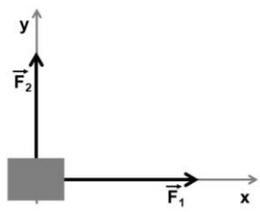
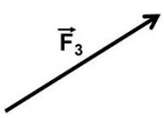
Q4. A block is moving with constant velocity on a frictionless horizontal surface. Three forces start acting on the block and the block **remains moving with the same initial constant velocity**. If the directions of the forces $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ are shown in the figure, then **the direction of $\overrightarrow{F_3}$ should be**:





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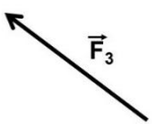

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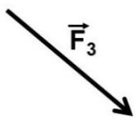

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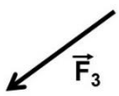

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Part II: Problems (Answer the following problems, two points each)

P1. If $\vec{A} = 2\,\hat{\imath} + 3\,\hat{\jmath} - 4\hat{k}$, $\vec{B} = 3\,\hat{\imath} - 2\,\hat{\jmath} + 6\,\hat{k}$, and $\vec{C} = \vec{A} + \vec{B}$ find the angle **between $\vec{C}$ and the positive y axis.**

$\vec{C} = \vec{A} + \vec{B} = 5\,\hat{\imath} + \hat{\jmath} + 2\,\hat{k}$

$$\beta = cos^{-1}\left(\frac{C_y}{|\vec{C}|}\right) = cos^{-1}\left(\frac{1}{\sqrt{5^2 + 1^2 + 2^2}}\right) = 79.5^o$$

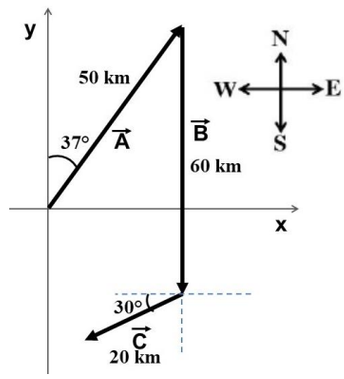
P2. A car undergoes the following displacements: First 50 km in a direction 37° east of north, then 60 km due south and finally 20 km 30° south of west. **Find the resultant displacement of the car in unit vector notation.**

$\vec{A} = (50\sin(37^o)\,\hat{\imath} + 50\cos(37^o)\,\hat{\jmath})km = (30.1\,\hat{\imath} + 40\,\hat{\jmath})\ km$

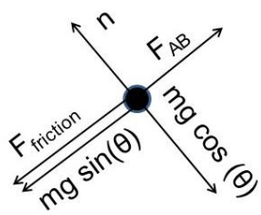
$\vec{B} = -60\,\hat{\jmath}\ km$

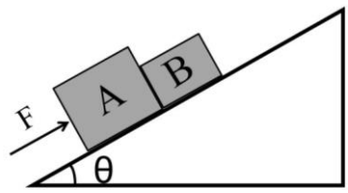
$\vec{C} = (-20\cos(30^o)\,\hat{\imath} - 20\sin(30^o)\,\hat{\jmath})\ km = (-17.3\,\hat{\imath} - 10\hat{\jmath})\ km$

$\vec{R} = \vec{A} + \vec{B} + \vec{C} = (12.8\,\hat{\imath} - 30\hat{\jmath})\ km$



P3. Block A and block B are placed on a rough incline as shown in the figure. A force F is applied on block A and the two blocks move up the incline. **Draw the free body diagram for block B.**





P4. An object moves along a straight line with velocity $v(t) = (32 - 2t^2)\ m/s$. Find the acceleration of the object **when it changes its direction of motion**.

$v(t) = 32 - 2t^2 = 0 \ \Rightarrow t = \sqrt{\frac{32}{2}} = 4\ s$

$a(t) = \frac{dv(t)}{dt} = 0 - 4t$

$a(2\ s) = -4(4) = -16\ m/s^2$

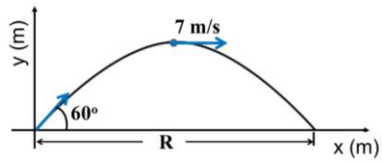
P5. A 5 kg block has a velocity of $(2\,\hat{\imath} + 3\,\hat{\jmath}\,)m/s$ at t = 0 s. It is accelerated at a constant rate for 3 seconds, at t = 3 s it has a velocity of $(23\,\hat{\imath} + 24\,\hat{\jmath}\,)m/s$. **Find the magnitude of the net force exerted on the block during this time interval.**

$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t} = \frac{21\,\hat{\imath} + 21\,\hat{\jmath}}{3} = (7\,\hat{\imath} + 7\,\hat{\jmath})m/s^2$

$\sum \vec{F} = m\vec{a} = (35\,\hat{\imath} + 35\,\hat{\jmath})N$

$\left|\sum \vec{F}\right| = \sqrt{(35)^2 + (35)^2}$ = 49.5 N

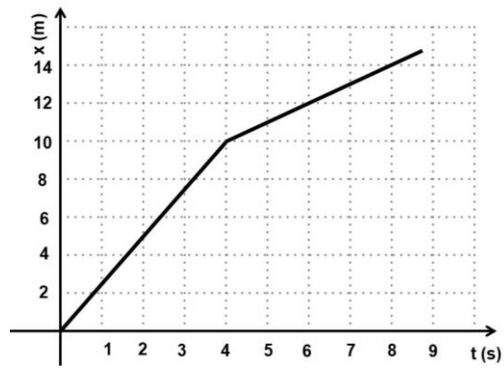
P6. A stone is projected from the ground level at an angle of 60° above the horizontal as shown in the figure. **If the speed of the stone at the maximum height is 7 m/s, find its horizontal range (R).**



$$v_{xi} = v_i \cos\theta \Rightarrow v_i = \frac{v_{xi}}{\cos\theta} = \frac{7}{\cos 60^o} = 14\ m/s$$

$$R = \frac{v_i^2 \sin 2\theta}{g} = \frac{(14)^2 \sin(120^o)}{10} = 17\ m$$

P7. A particle moves along the x, its position as a function of time is shown in the figure. Find the **average acceleration** of the particle in the time interval from **t = 3 s to t = 6 s**.



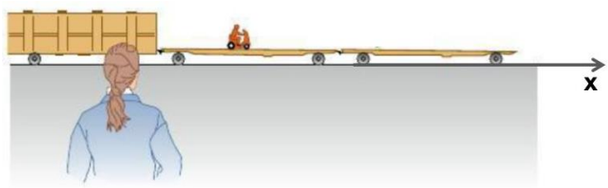
$v_x(6\ s)$ = slope of the tangent = $\frac{14-10}{8-4} = 1\ m/s$

$v_x(3\ s)$ = slope of the tangent = $\frac{10-0}{4-0} = 2.5\ m/s$

$$a_{av-x} = \frac{v_{xf} - v_{xi}}{\Delta t} = \frac{1 - 2.5}{3} = -0.5\ m/s^2$$

P8. A railroad flatcar is traveling to the right at a speed of **13 m/s relative to a girl** standing on the ground. A man is riding a motor scooter on the flatcar as shown in the figure. If the **scooter's velocity relative to the girl is $+18\ \hat{\imath}\ m/s$**, what is the **velocity of the scooter relative to the flatcar** in unit vector notation.

s: scoter
g: girl
c: car



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

$$\vec{v}_{s/c} = +18\ \hat{\imath} - 13\ \hat{\imath} = +5\ \hat{\imath}\ m/s$$

P9. The only two forces acting on a 50 kg box are given by $\vec{F}_1 = (120\ \hat{\imath} + 290\ \hat{\jmath})\ N$, $\vec{F}_2 = (80\ \hat{\imath} - 140\ \hat{\jmath})\ N$. **Find the magnitude of the acceleration of the box.**

$$\sum \vec{F} = \vec{F}_1 + \vec{F}_2 = (200\ \hat{\imath} + 150\ \hat{\jmath})\ N$$

$$\vec{a} = \frac{\sum \vec{F}}{m} = (4\ \hat{\imath} + 3\ \hat{\jmath})\ m/s^2$$

$$|\vec{a}| = \sqrt{4^2 + 3^2} = 5\ m/s^2$$

P10. A wheel 4 m in diameter rotates at a constant rate of 20 rev/min. **Find the magnitude of the radial acceleration of the wheel.**

$$v = \frac{20\ (2\pi R)}{60} = \frac{20\ (2\pi(2))}{60} = 4.19\ m/s$$

$$a_r = \frac{v^2}{R} = \frac{4.19^2}{2} = 8.8\ m/s^2$$

P11. A block moves along the positive x-axis with constant acceleration. The block **starts from rest** and its speed after it has traveled 9 m is 6 m/s. **Find the speed of the block when it is 3 m from the starting point.**

$$v_{xf}^2 = v_{xi}^2 + 2a_x\Delta x$$

$$6^2 = 0 + 2a_x(9) \Rightarrow\ a_x = \frac{6^2}{18} = 2\ m/s^2$$

$$v_{xf}^2 = v_{xi}^2 + 2a_x\Delta x$$

$$v_{xf}^2 = 0 + 2a_x(3) = 2(2)(3) = 12$$

$$v_x(x = 3m) = \sqrt{12} = 3.5\ m/s$$

P12. At t = 0 s, a stone is released from a height of 300 m above the ground. At the same time, another stone is thrown vertically upward from the ground with initial speed of 100 m/s. **Find the time at which the two stones will meet in air.**

Δy_1 covered by the stone which is thrown upward from the ground (Δy_1 is positive)

$$\Delta y_1 = v_{yi}t - \frac{1}{2}gt^2 = 100t - 5t^2$$

Δy_2 covered by the stone which is released from above (Δy_2 is negative)

$$\Delta y_2 = v_{yi}t - \frac{1}{2}gt^2 = -5t^2$$

$$300 = \Delta y_1 - \Delta y_2 = 100t - 5t^2 - (-5t^2) = 100t$$

$$t = 3\ s$$