



## PHYSICS TEST

*Les calculatrices et les documents ne sont pas autorisés. Le barème est donné à titre indicatif.*

***Réponses exclusivement sur le sujet. Si vous manquez de place, vous pouvez utiliser le verso des pages.***

### Exercise 1. Lecture questions [2.5 POINTS](No negative points )

Select the correct answer

1. A motion is said uniform if

- a. Its trajectory is a straight line.
- b. Its acceleration is constant over time.
- c. Its velocity is constant over time.
- d. Its velocity and acceleration vary very few over time.

2. In polar coordinates,  $(\vec{u}_\rho, \vec{u}_\theta)$ , position vector  $\vec{r}(t) = \overrightarrow{OM}(t)$  has for expression:

- a.  $\vec{r}(t) = \rho \vec{u}_\rho + \theta \vec{u}_\theta$
- b.  $\vec{r}(t) = \rho \vec{u}_\rho$
- c.  $\vec{r}(t) = \theta \vec{u}_\rho + \rho \vec{u}_\theta$
- d.  $\vec{r}(t) = \rho \vec{u}_\theta$

3. A moving particle has a rectilinear trajectory along the X-axis. Its trajectory equation is  $x(t) = 10 - 2t^2$ .

- a. The motion is uniform.
- b. The motion is uniformly circular.
- c. Le mouvement est decelerated.
- d. Acceleration magnitude is  $2 \text{ m/s}^2$

4. Consider a moving particle whose position at each instant  $t$  is given by its position vector  $\vec{r}(t) = \overrightarrow{OM}(t)$ . Acceleration vector  $\vec{a}(t)$  of this motion has for expression:

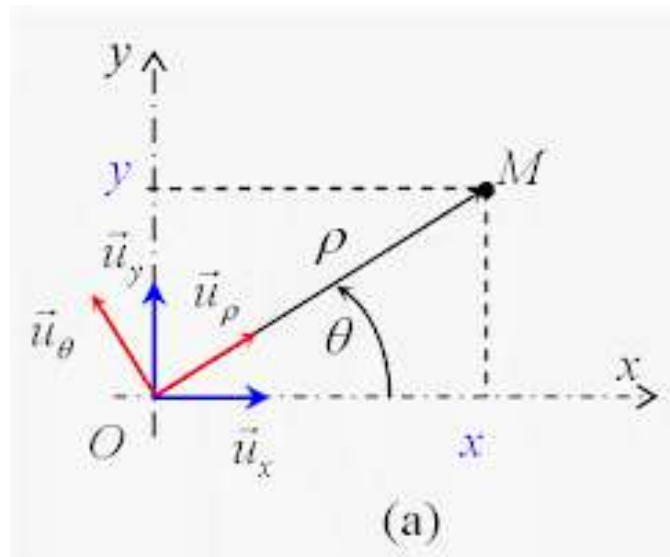
- a.  $\vec{a}(t) = \frac{dr(t)}{dt^2}$
- b.  $\vec{a}(t) = \frac{d^2\vec{r}(t)}{dt^2}$
- c.  $\vec{a}(t) = \left[ \frac{d\vec{r}(t)}{dt} \right]^2$
- d.  $a(t) = \sqrt{r(t)}$

5. Two vectors are perpendicular if their scalar product is equal to zero.

- a. TRUE
- b. FALSE

**EXERCISE 2 : CARTESIAN AND POLAR COORDINATES [8 POINTS]**

Diagram below shows on the same plane, polar and cartesian coordinates representations.



1. Express  $\vec{u}_\rho$  and  $\vec{u}_\theta$ , the unit vectors of the polar basis, as functions of  $\theta$  and cartesian unit vectors  $\vec{u}_x$  and  $\vec{u}_y$ .

2. a. Calculate  $\frac{d\vec{u}_\rho}{d\theta}$ , derivative of unit vector  $\vec{u}_\rho$  with respect to  $\theta$  angle.

- b. Express  $\frac{d\vec{u}_\rho}{d\theta}$  as a function of  $\vec{u}_\theta$

3. a. Calculate  $\frac{d\vec{u}_\theta}{d\theta}$ , derivative of unit vector  $\vec{u}_\theta$  with respect to  $\theta$ .

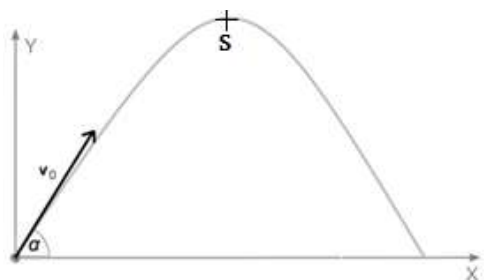
- b. Express  $\frac{d\vec{u}_\theta}{d\theta}$  as a function of  $\vec{u}_\rho$

4.  $M$  point represents position of a moving particle. Express its position vector  $\vec{r}(t) = \overrightarrow{OM}(t)$  in cartesian basis and in polar basis.

5. Give the general expression of velocity vector  $\vec{v}(t)$  and then give its expression in polar basis. Detail your calculations.

### EXERCISE 3 : MOTION OF A PROJECTILE [5,5 POINTS]

Consider a projectile launched from the origin point (0;0) of a cartesian frame at instant  $t = 0$  s. It is launched by forming an angle  $\alpha$  with the X-axis. S point, called the apex, corresponds to the top of the trajectory.



$\vec{r}(t) = \overrightarrow{OM}$ , the position vector, is :

$$\overrightarrow{OM} = (v_0 \cos \alpha) \cdot t \vec{u}_x + \left[ (v_0 \sin \alpha) \cdot t - 5t^2 \right] \vec{u}_y$$

1. a. Give the hourly equations,  $x(t)$  and  $y(t)$ , of this motion.

- b. Give the trajectory equation of this motion.

2. Give the expression of velocity vector  $\vec{v}(t)$ . Express its magnitude.

3. At the top of trajectory,  $V_y$  ( the Y-axis component of velocity vector) is equal to zero. Calculate the maximal height reached by the projectile as a function of  $V_0$  et  $\alpha$  angle.

#### **EXERCISE 4 : ACCELERATION IN POLAR COORDINATES [4 POINTS]**

For any motion, acceleration expression in polar coordinates is  $\vec{a}(t) = (\ddot{\rho} - \rho\dot{\theta}^2)\vec{u}_\rho + (\rho\ddot{\theta} + 2\dot{\rho}\dot{\theta})\vec{u}_\theta$

1. What is the acceleration expression if the motion is circular ? Justify your answer.

2. What is the acceleration vector expression if the motion, in addition of being circular, is also uniform. Justify your answer.