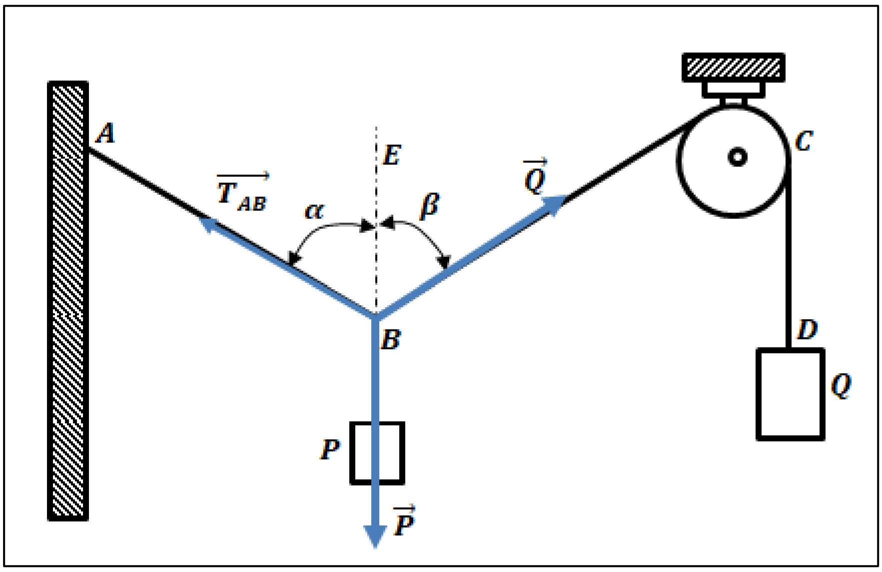
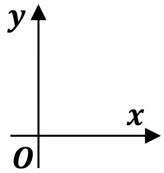
Solution RATIONAL MECHANICAL EXAMINATION **17/01/2026**

Department: 2nd Year **ST** Duration: 1h 30 min

Solution Exercise 01 : $(\mathbf{6}\ \boldsymbol{Pts})$



$(\mathbf{1}\ \boldsymbol{Pt})$



At point B:

$$\overrightarrow{T_{AB}} + \vec{Q} + \vec{P} = \vec{0}$$

Equilibrium equation:

$$\sum F/x = Q \times \sin\beta - T_{AB} \times \sin\alpha = 0 \quad (1) \quad (\mathbf{1,5}\ \boldsymbol{Pts})$$

$$\sum F/y = Q \times \cos\beta + T_{AB} \times \cos\alpha - P = 0 \quad (2) \quad (\mathbf{1,5}\ \boldsymbol{Pts})$$

From equation (1), we get:

$$T_{AB} = \frac{Q \times \sin\beta}{\sin\alpha} = \frac{10 \times \sin 60^o}{\sin 45^o} = 12,25\ (KN) \quad (3) \quad (\mathbf{1}\ \boldsymbol{Pt})$$

Substituting equation (3) into equation (2)

$$P = Q \times \cos\beta + T_{AB} \times \cos\alpha = 10 \times \cos 60^o + 12,25 \times \cos 45^o = 13,66\ (KN) \quad (\mathbf{1}\ \boldsymbol{Pt})$$

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Solution Exercise 02: $(6\ Pts)$

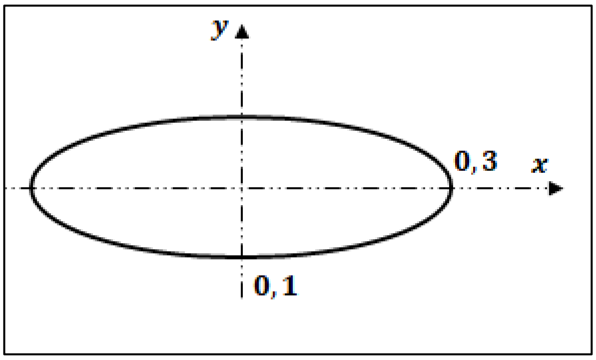
$A\hat{B}O = A\hat{O}B = \varphi$

The coordinates of point M are denoted by x and y.

$$x = OP = OA\ cos\varphi + AM\ cos\varphi = 0,3\ cos\ 2\pi t \quad ==> \quad x^2 = 0,3^2 cos^2 2\pi t$$
$$y = MP = MB\ sin\ \varphi = 0,1\ sin\ 2\pi t \qquad\qquad y^2 = 0,1^2 sin^2 2\pi t$$
$(1\ Pt)$

We have: $\frac{x^2}{0,3^2} = \frac{y^2}{0,1^2} = 1$ $(1\ Pt)$

The trajectory is an ellipsis with center O.



$$V_x = \dot{x} = -0,6\pi\ sin\ 2\pi t \qquad\qquad V_y = \dot{y} = 0,2\pi\ cos\ 2\pi t$$

$$V = \sqrt{V_x{}^2 + V_y{}^2} = \pi\sqrt{0,36\ sin^2\ 2\pi t + 0,04\ cos^2\ 2\pi t}$$
$(1\ Pt)$

$$a_x = \ddot{x} = \dot{V}_x = -1,2\ \pi^2 cos\ 2\pi t \qquad\qquad a_y = \ddot{y} = \dot{V}_y = -0,4\ \pi^2 sin\ 2\pi t$$

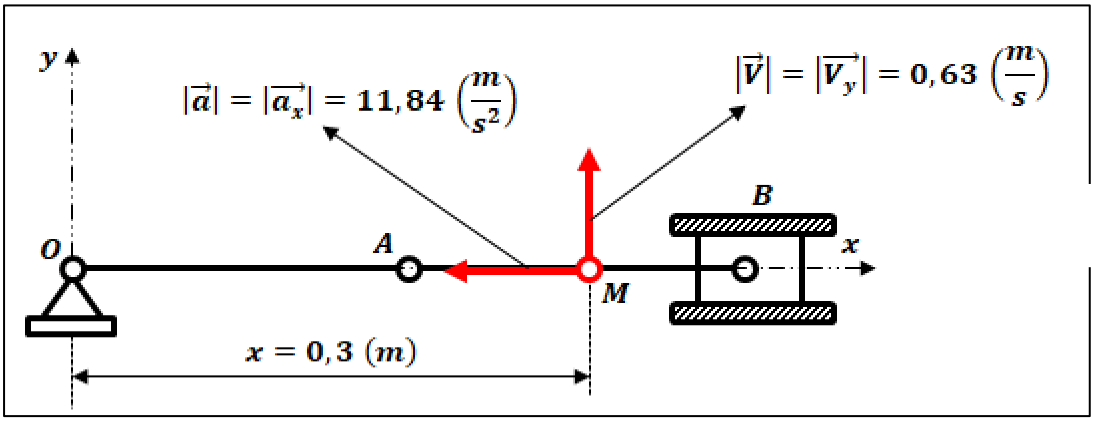
$$a = \pi^2\sqrt{1,44\ cos^2\ 2\pi t + 0,16\ sin^2\ 2\pi t}$$
$(1\ Pt)$

At time $t = 0$ $\quad x = 0,3 \quad y = 0$ $(0,5\ Pt)$

$V_x = 0 \quad V_y = 0,63\left(\frac{m}{s}\right) \quad V = V_y$ $(0,5\ Pt)$

$a_x = -11,84\left(\frac{m}{s^2}\right) \quad a_y = 0 \quad a = a_x$ $(0,5\ Pt)$

$cos(\vec{V}; x) = 0 \quad cos(\vec{V}; y) = 1$



$(0,5\ Pt)$

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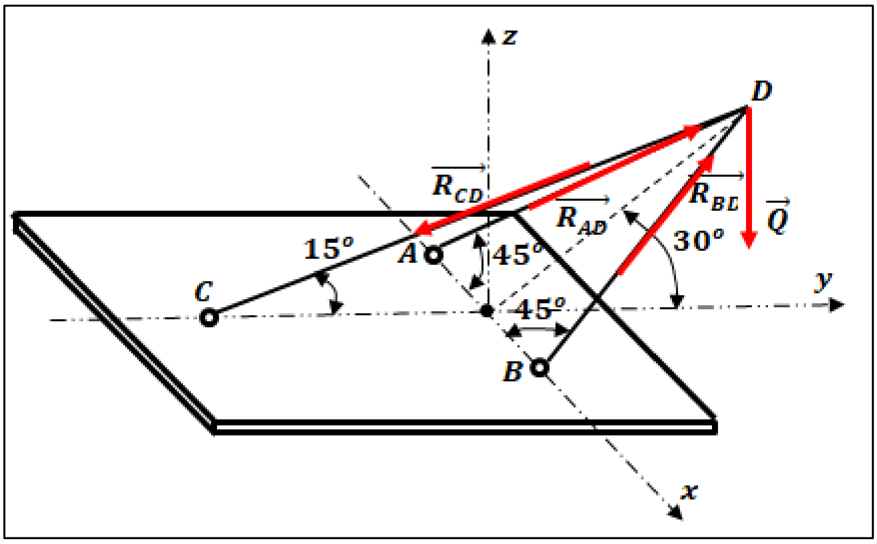
Solution Exercise 03 : ($\boldsymbol{8\ Pts}$)



($\boldsymbol{1\ Pt}$)

$$\sum \vec{F} = \vec{Q} + \overrightarrow{R_{CD}} + \overrightarrow{R_{AD}} + \overrightarrow{R_{BD}}$$

Equilibrium equations:

$\sum F/_x = +R_{AD}\cos 45^o - R_{BD}\cos 45^o + 0 = 0$ (1) ($\boldsymbol{1\ Pt}$)

$\sum F/_y = -R_{CD}\cos 15^o + R_{AD}\sin 45^o\cos 30^o + R_{BD}\sin 45^o\cos 30^o = 0$ (2) ($\boldsymbol{2\ Pts}$)

$\sum F/_z = -R_{CD}\sin 15^o + R_{AD}\sin 45^o\sin 30^o + R_{BD}\sin 45^o\sin 30^o - Q = 0$ (3) ($\boldsymbol{2\ Pts}$)

De l'équation (1), on tire :

$R_{AD} = R_{BD}$ **(a)**

Remplaçons l'équation (a) dans l'équation (2), on tire :

$R_{CD} = 2R_{AD}\dfrac{\sin 45^o\cos 30^o}{\cos 15^o}$ **(b)**

Remplaçons l'équation (b) dans l'équation (3), on tire :

$-2R_{AD}\sin 45^o\cos 30^o\tan 15^o + 2R_{AD}\sin 45^o\sin 30^o - Q = 0$

$2R_{AD}\sin 45^o(-\cos 30^o\tan 15^o + \sin 30^o) = Q$

$$R_{AD} = \frac{Q}{2.\sin 45^o(-\cos 30^o\tan 15^o + \sin 30^o)}$$

$R_{AD} = \dfrac{10^3}{2.\sin 45^o(-\cos 30^o\tan 15^o + \sin 30^o)} = 2,64\ 10^3\ (kN) = R_{BD}$ ($\boldsymbol{1\ Pt}$)

$R_{CD} = 2R_{AD}\dfrac{\sin 45^o\cos 30^o}{\cos 15^o} = 2 \times 2,,64 \times \dfrac{\sin 45^o\cos 30^o}{\cos 15^o} = 3,35\ 10^3\ (kN)$ ($\boldsymbol{1\ Pt}$)