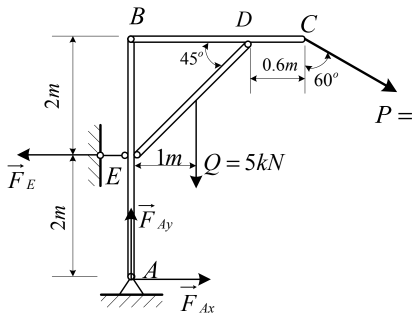
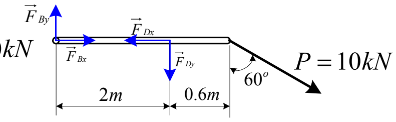
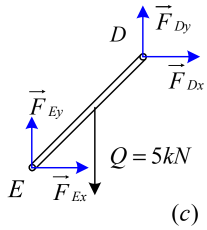
一、解：受力图（每个 4 分）



(a)



(b)



(c)

（a） ***(6 分)***

$$\sum m_A = 0 \qquad F_E \times 2 - P \times \cos 60^o \times 2.6 - P \times \sin 60^o \times 4 - Q \times 1 = 0$$

$$\therefore F_E = 26.32kN$$

$$\sum F_x = 0 \qquad F_{Ax} - F_E + P \times \sin 60^o = 0$$

$$\therefore F_{Ax} = 17.66kN$$

$$\sum F_y = 0 \qquad F_{Ay} - Q - P \times \cos 60^o = 0$$

$$\therefore F_{Ay} = 10kN$$

（b）***（2 分）***

$$\sum m_B = 0 \qquad F_{Dy} \times 2 + P \times \cos 60^o \times 2.6 = 0$$

$$\therefore F_{Dy} = -6.5kN$$

(c) ***（5 分）***

$$\sum m_E = 0 \qquad F_{Dy} \times 2 - F_{Dx} \times 2 - Q \times 1 = 0$$

$$\therefore F_{Dx} = -18kN$$

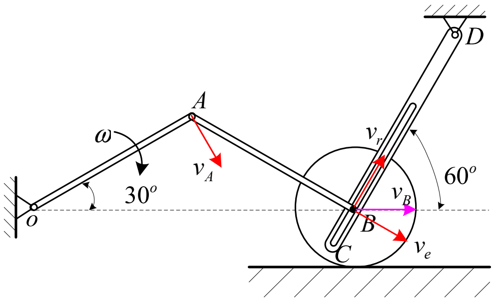
$$\sum F_x = 0 \qquad F_{DX} + F_{EX} = 0$$

$$\therefore F_{Ex} = 18kN$$

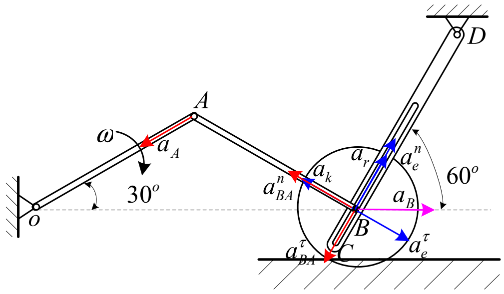
$$\sum F_y = 0 \qquad F_{Dy} + F_{Ey} - Q = 0$$

$$\therefore F_{Ey} = 11.5kN$$

二、解：***(各 6 分)***



(*a*)



(*b*)

（a）***(6 分)***

OA: $v_A = 3r\omega$

AB: 速度投影法得 $v_B = v_A = 3r\omega$ 且：$\omega_{AB} = \omega$

B 点的速度合成：$\vec{v_B} = \vec{v_e} + \vec{v_r}$

$v_e = v_B \cos 30^o = \dfrac{3\sqrt{3}}{2} r\omega$ $v_r = v_B \sin 30^o = \dfrac{3}{2} r\omega$ $\therefore \omega_{CD} = \dfrac{v_e}{3r} = \dfrac{\sqrt{3}}{2}\omega$

（b）***(7 分)***

OA: $a_A = 3r\omega^2$

AB: $\vec{a_B} = \vec{a_A} + \vec{a_{BA}^n} + \vec{a_{BA}^\tau}$

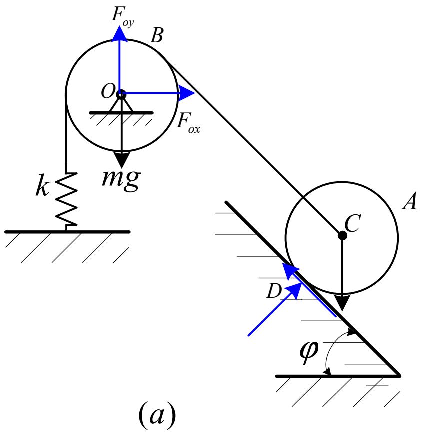
B 点的加速度合成：$\vec{a_B} = \vec{a_e^n} + \vec{a_e^\tau} + \vec{a_r} + \vec{a_k}$

上两式向 AB 连线投影：$a_A \times \cos 60^o + a_{BA}^n = -a_e^\tau + a_k$

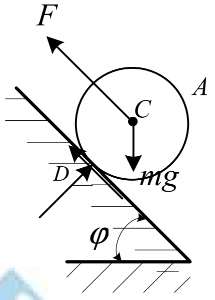
$a_{BA}^n = AB \times \omega_{AB}^2 = 3r\omega^2$ ； $a_k = 2 \times v_r \times \omega_{CD} = \dfrac{3\sqrt{3}}{2} r\omega^2$ ； $a_e^\tau = BD \times \alpha_{CD}$

$\therefore \alpha_{CD} = (\dfrac{3\sqrt{3}}{2} - \dfrac{9}{2})\omega^2 = -1.9\omega^2$

三、解：***(各 2 分)***



(*a*)



(*b*)

整体：（a）

动能***(6 分)***：$T=\frac{1}{2}J_o\omega_o^2+\frac{1}{2}mv_C^2+\frac{1}{2}J_C\omega_C^2$

$\because J_o=J_C=\frac{1}{2}mr^2 \quad \omega_o=\omega_C=\omega \qquad v_C=r\omega \qquad \therefore T=mv_C^2$

外力功***(4 分)***：$W=\frac{1}{2}k\frac{h^2}{\sin^2\varphi}+mgh$

动能定理***(6 分)***：$mv_C^2=\frac{1}{2}k\frac{h^2}{\sin^2\varphi}+mgh$

对时间 t 求导 $2mv_Ca_C=(k\frac{h}{\sin\varphi}+mg\sin\varphi)v_C$

$$\therefore a_C=\frac{1}{2}g\sin\varphi+\frac{kh}{2m}$$

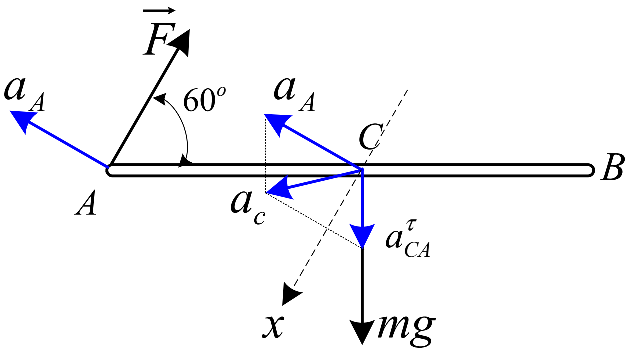
(b) ***(5 分)***

$J_D\alpha=-Fr+mgr\cos\varphi$

$\because \alpha=\frac{a_C}{r}; \quad J_D=\frac{3}{2}mr^2$

$\therefore F=mg\cos\varphi-\frac{3}{4}mg\sin\varphi-\frac{3}{4}kh$

四、解：*(8 分)*



$J_C\alpha = F\sin 60^o \times \frac{l}{2}$ *(4 分)*

$\overrightarrow{a_C} = \overrightarrow{a_A} + \overrightarrow{a_{CA}^{\tau}}$　　$a_{Cx} = a_{CA}^{\tau}\cos 30^o = \frac{\sqrt{3}}{4}l\alpha$ *(4 分)*

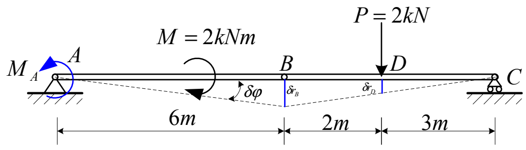
$J_C = \frac{1}{12}ml^2$

$ma_{Cx} = mg\cos 30^o - F$ *(4 分)*

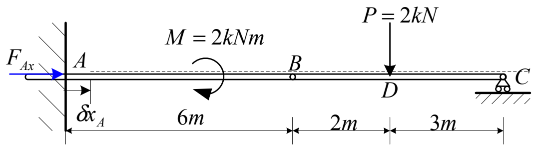
$\therefore \alpha = \frac{6\sqrt{3}g}{(3\sqrt{3}+4)l} = \frac{54+24\sqrt{3}}{11}\frac{g}{l}$ *(3 分)*

$F = \frac{18+6\sqrt{3}}{11}mg$ *(2 分)*

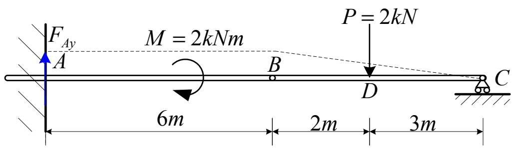
五、解：***(各 4 分)***



(a)



(b)



(c)

（a）***(6 分)***

$$-M_A\delta\varphi + M\delta\varphi + P\delta r_D = 0$$

$$\delta r_B = 6\times\delta\varphi \qquad \delta r_D = \frac{3}{5}\delta r_B \quad \therefore \delta r_D = \frac{18}{5}\delta\varphi$$

$$\therefore M_A = 9.2kNm$$

(b)　***(3 分)***

$$F_{Ax}\delta x_A = 0 \qquad \therefore F_{Ax} = 0$$

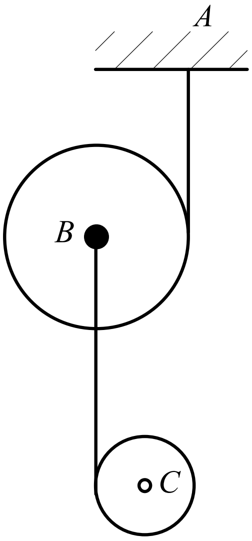
(c)　***(4 分)***

$$F_{Ay}\delta y_A - P\delta r_D = 0$$

$$\delta y_A = \delta r_B \qquad \delta r_D = \frac{3}{5}\delta r_B$$

$$F_{Ay} = \frac{3}{5}P = 1.2kN$$

六、解：***(4 分)***



动能：$T = \frac{1}{2}mx_B^2 + \frac{1}{2}\times\frac{1}{2}mr^2\frac{x_B^2}{r^2} + \frac{1}{4}mx_C^2 + \frac{1}{8}mx_C^2 = \frac{7}{8}mx_B^2 + \frac{3}{8}mx_C^2 - \frac{1}{4}mx_Bx_c$ ***(6 分)***

$V = -mgx_B - \frac{1}{2}mx_C$ ***(4 分)***

方程***(6 分)***

$$\frac{7}{4}ma_B - \frac{1}{2}ma_c - mg = 0$$

$$\frac{3}{4}ma_C - \frac{1}{2}ma_B - \frac{1}{2}mg = 0$$

解方程***(5 分)*** $a_B = \frac{16}{17}g \quad a_C = \frac{22}{17}g$