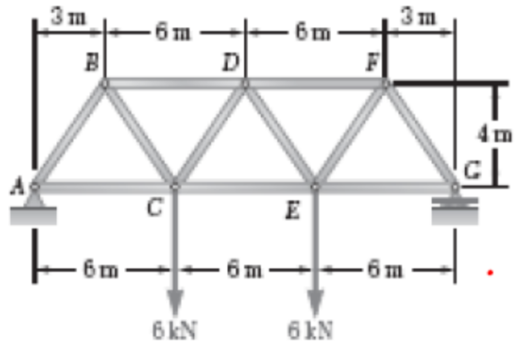
Set 12A

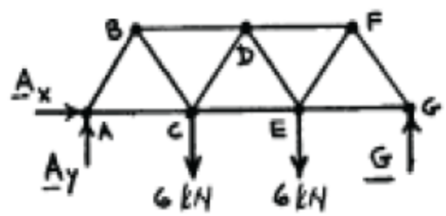


PROBLEM 6.19

Determine the force in each member of the Warren bridge truss shown. State whether each member is in tension or compression.

Before drawing the FBD of a pin, assume all those members for which forces are not known to be in tension

SOLUTION



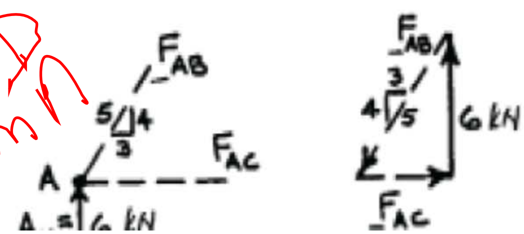
Free body: Truss $\Sigma F_x = 0: \quad A_x = 0$

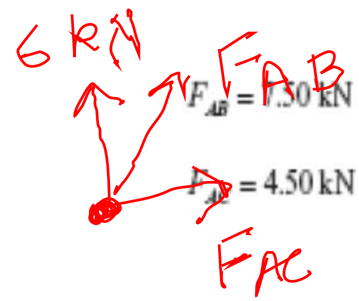
Due to symmetry of truss and loading

$$A_y = G = \frac{1}{2}\text{Total load} = 6\text{ kN} \uparrow$$

Free body: Joint A: $\frac{F_{AB}}{5} = \frac{F_{AC}}{3} = \frac{6\text{ kN}}{4}$

FBD of pin

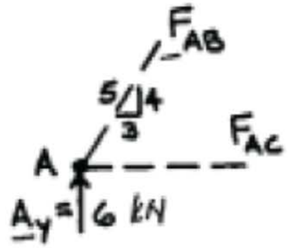




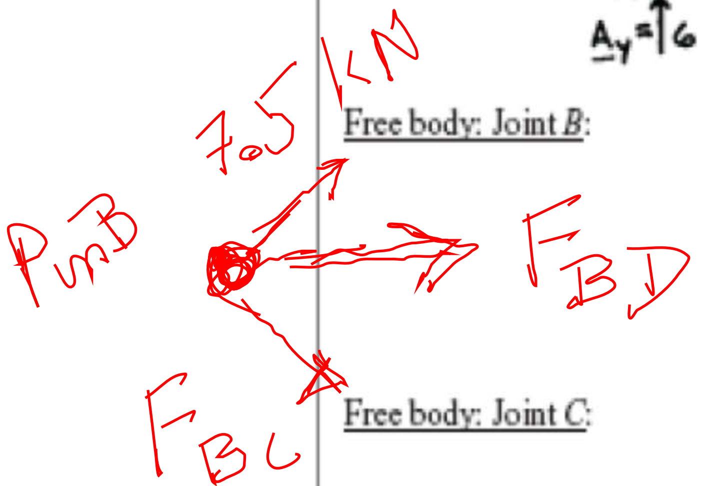
$F_{AB} = 7.50\text{ kN}$ C ◀

$F_{AC} = 4.50\text{ kN}$ T ◀

Use static equilibrium of pin A to find forces in AB and AC



$$F_{AC} = 4.50\text{ kN} \quad T \blacktriangleleft$$

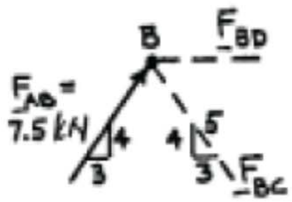


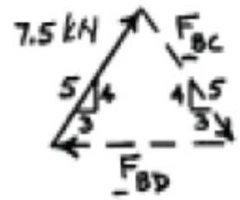
Free body: Joint B:

$$\frac{F_{BC}}{5} = \frac{F_{BD}}{6} = \frac{7.5\text{ kN}}{5}$$

$$F_{BC} = 7.50\text{ kN} \quad T \blacktriangleleft$$

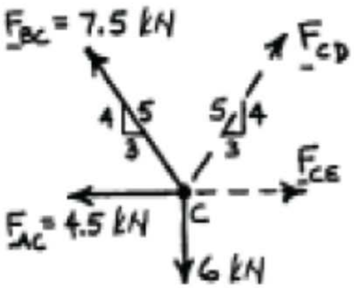
$$F_{BD} = 9.00\text{ kN} \quad C \blacktriangleleft$$





Use static equilibrium of pin B to find forces in BD and BC

Free body: Joint C:



$$+\uparrow \Sigma F_y = 0: \quad \frac{4}{5}(7.5) + \frac{4}{5}F_{CD} - 6 = 0$$

$$F_{CD} = 0 \blacktriangleleft$$

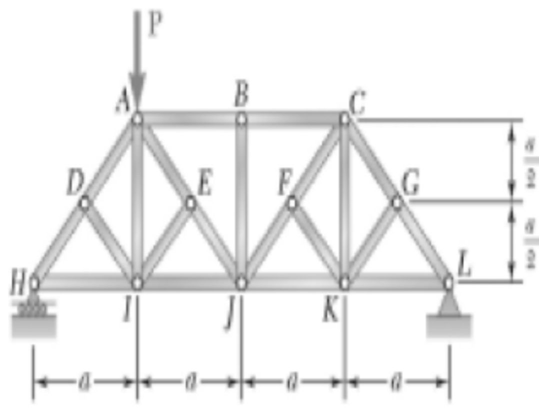
$$\xrightarrow{+} \Sigma F_x = 0: \quad F_{CE} - 4.5 - \frac{3}{5}(7.5) = 0$$

$$+\uparrow F_{CE} = +9\text{ kN} \qquad F_{CE} = 9.00\text{ kN} \quad T \blacktriangleleft$$

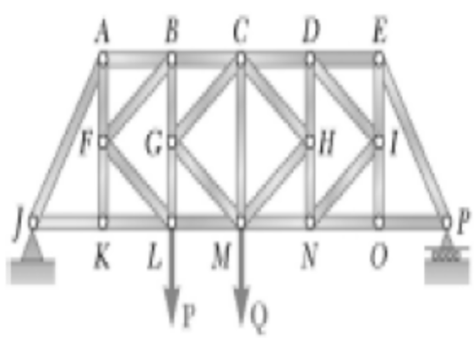
Truss and loading symmetrical about ℄

PROBLEM 6.31

For the given loading, determine the zero-force members in each of the two trusses shown.



(a)



(b)

SOLUTION

Truss (*a*):

FB: Joint B: $F_{BJ} = 0$

FB: Joint D: $F_{DI} = 0$

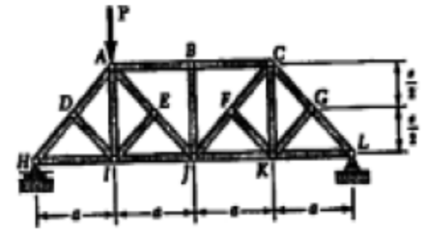
FB: Joint E: $F_{EI} = 0$

FB: Joint I: $F_{AI} = 0$

FB: Joint F: $F_{FK} = 0$

FB: Joint G: $F_{GK} = 0$

FB: Joint K: $F_{CK} = 0$



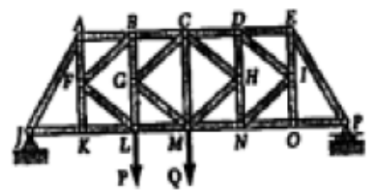
(*a*)

The zero-force members, therefore, are $AI, BJ, CK, DI, EI, FK, GK$ ◀

Truss (*b*):

FB: Joint K: $F_{FK} = 0$

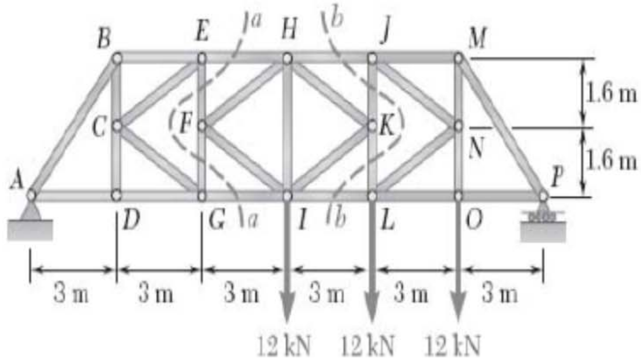
FB: Joint O: $F_{IO} = 0$



(*b*)

The zero-force members, therefore, are FK and IO ◀

All other members are either in tension or compression.

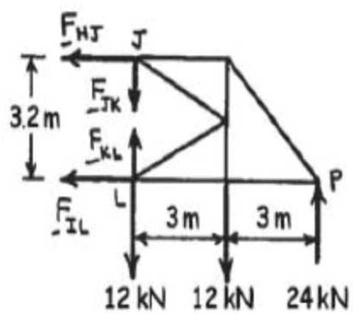


PROBLEM 6.62

Determine the force in members *HJ* and *IL* of the truss shown. (*Hint:* Use section *bb*.)

SOLUTION

See the solution to Problem 6.61 for free body diagram and analysis to determine the reactions at supports *A* and *P*.



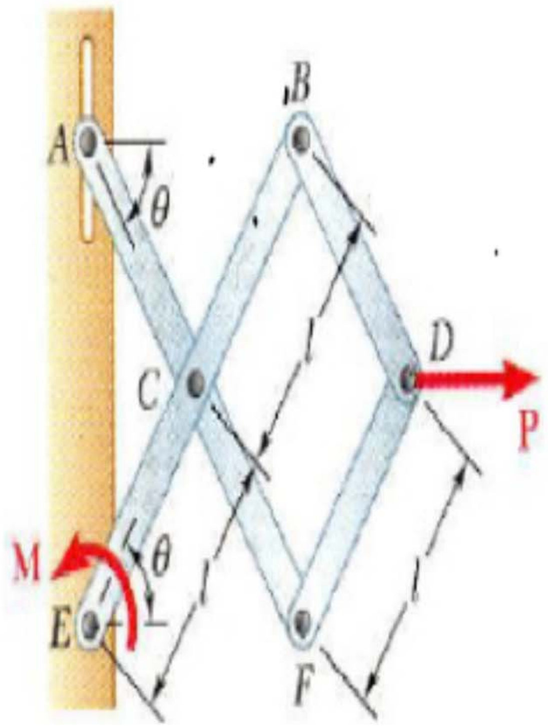
$$\mathbf{A}_x = 0; \quad \mathbf{A}_y = 12.00 \text{ kN} \uparrow; \qquad \mathbf{P} = 24.0 \text{ kN} \uparrow$$

$$+\circlearrowleft \Sigma M_L = 0: \quad F_{HJ}(3.2 \text{ m}) - (12 \text{ kN})(3 \text{ m}) + (24 \text{ kN})(6 \text{ m}) = 0$$

$$F_{HJ} = -33.75 \text{ kN} \qquad\qquad F_{HJ} = 33.8 \text{ kN} \quad C \blacktriangleleft$$

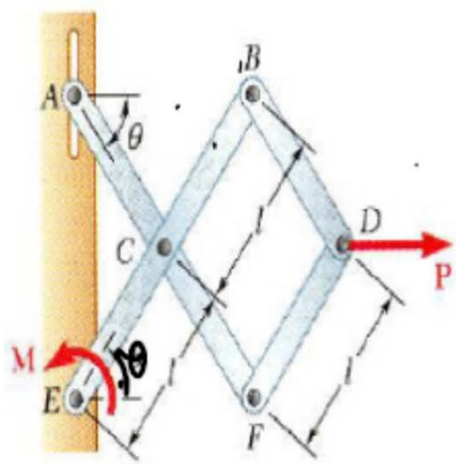
$$\xrightarrow{+} \Sigma F_x = 0: \quad 33.75 \text{ kN} - F_{IL} = 0$$

$$F_{IL} = +33.75 \text{ kN} \qquad\qquad F_{IL} = 33.8 \text{ kN} \quad T \blacktriangleleft$$



Find M to maintain equilibrium of the mechanism use PVW

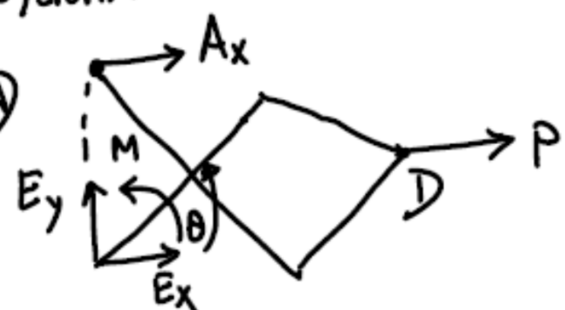
Example: System of inter connected rigid bodies



Find M to maintain equilibrium of the mechanism (using PVW)

System: entire mechanism. FBD

1. FBD



Using Euler's axioms, unknown M can't be find using this FBD alone. (check)

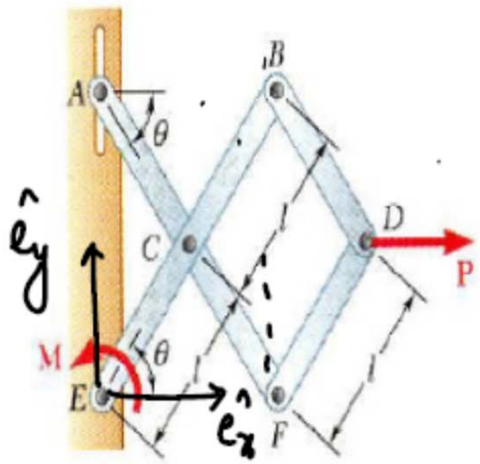
2. G.C. : θ 3. Allow $\theta \to \theta \to \theta + \delta\theta$

4. E_x, E_y are workless because $\delta\theta$ can't violate
Constraint at E (E remains stationary)
A_x is also workless $\delta \underline{r}_A \perp A_x$

only P and M will do virtual work.

5. We need to find $\delta \underline{r}_D$

6. Working csys $\hat{e}_x - \hat{e}_y$ with origin at E (fixed - not affected by virtual displacement)



Find M to maintain equilibrium of the mechanism

$$\underline{r}_D = 3l\cos\theta\,\hat{e}_x + l\sin\theta\,\hat{e}_y$$

$$\delta\underline{r}_D = -3l\sin\theta\,\delta\theta\,\hat{e}_x + l\cos\theta\,\delta\theta\,\hat{e}_y$$

7. PVW:

$$\delta U = \underbrace{\sum \underline{F}_i \cdot \delta\underline{r}_i}_{\text{all external forces (noncouple)}} + \underbrace{\sum \underline{M}_j \cdot \delta\underline{\theta}_j}_{\text{(all RB's)}} = 0$$

$$\delta U = P\hat{e}_x \cdot \delta \underline{r}_D + M\delta\theta$$ external torque on RB ECB only

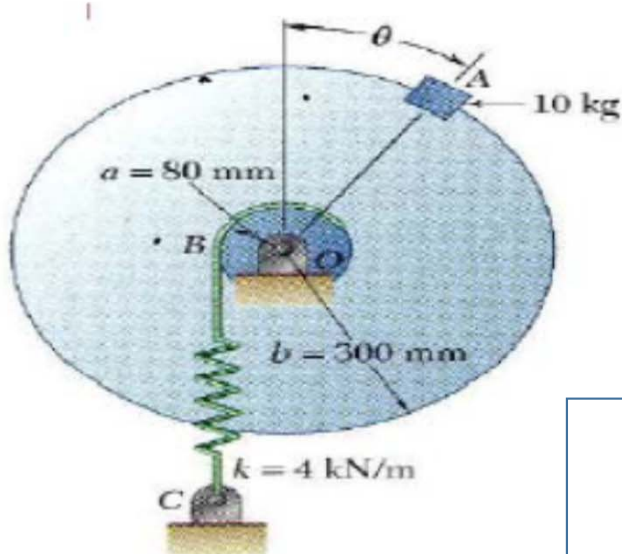
$$= P\hat{e}_x \cdot \left[-3l\sin\theta\,\delta\theta\,\hat{e}_x + l\cos\theta\,\delta\theta\,\hat{e}_y\right] + M\delta\theta$$

$$= -3Pl\sin\theta\,\delta\theta + M\delta\theta = 0$$

$$= -\delta\theta\left[-3Pl\sin\theta + M\right] = 0$$

Since $\delta\theta$ is arbitrary $\Rightarrow$

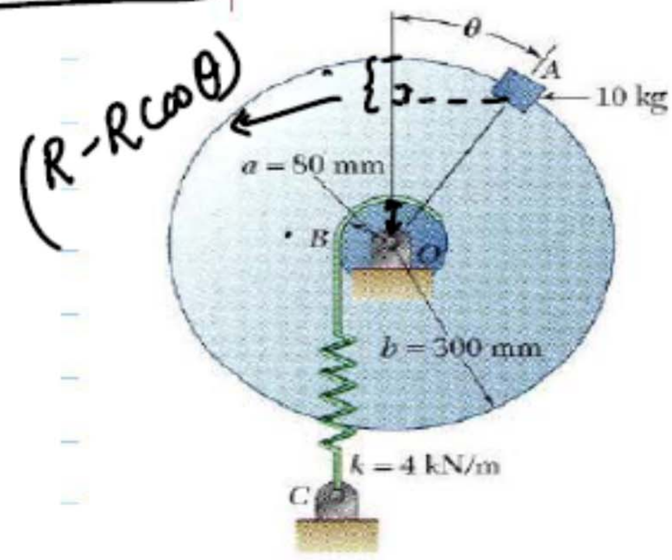
$$-3Pl\sin\theta + M = 0 \Rightarrow \boxed{M = 3Pl\sin\theta}$$



Use PVW

Knowing that the spring BC is unstretched when $\theta = 0$, determine the position or positions of equilibrium and state whether the equilibrium configurations are stable or unstable.

Example

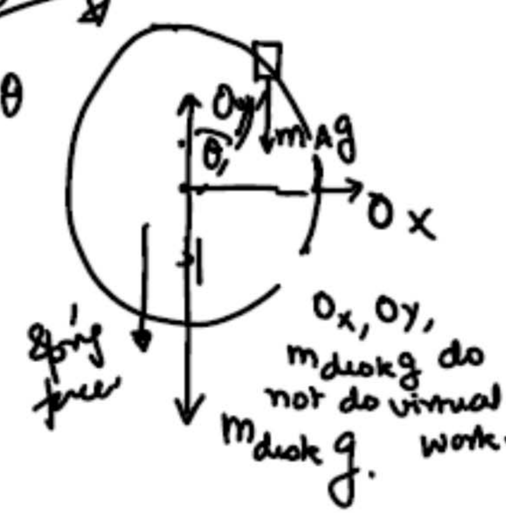


Knowing that the spring BC is unstretched when $\theta = 0$, determine the position or positions of equilibrium ~~and state whether~~

System = Disk + bead

1. FBD

2. G.C.: θ



Since only the spring force and $m_A g$ could do virtual work, and both of them are conservative forces equilibrium is satisfied at that θ where

Satisfied at that θ where

$\frac{dV}{d\theta} = 0$ where $V = $ P.E. of System

$V(\theta) = V^{\text{spring force}} + V^{\text{bead weight}}$

We need a datum: Since spring is unstretched at $\theta = 0$, we take $\theta = 0$ as datum of both potentials

$V^{\text{bead weight}}(\theta) = -m_A g b(1 - \cos\theta)$

$V^{\text{spring}}(\theta) = \frac{1}{2}k(x^{\text{extension}})^2 = \frac{1}{2}k(a\theta)^2$

$V(\theta) = -m_A g b + m_A g b \cos\theta + \frac{1}{2}k(a\theta)^2$

$\frac{dV}{d\theta} = 0 \Rightarrow \boxed{ka^2\theta = m_A g b \sin\theta}$

$a = .08$ m

$b = .3$ m

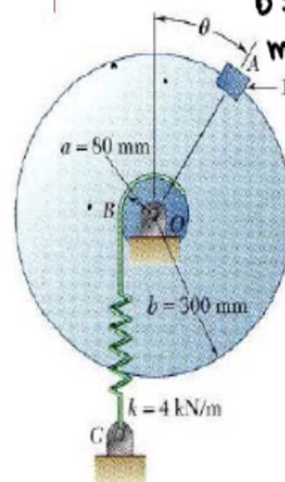
$m_A = 10$ kg

$k = 4\,\text{kN m}^{-1}$

Soln $\theta = 0$ rad

$= .902$ rad.

So equilibrium can exist with $\theta = 0$ or $.902$ rad



$\theta_{eq} = 0$

$$\left.\frac{d^2V}{d\theta^2}\right|_{\theta_{eq}=0} = -m_A g b + k a^2.$$

Using the numbers given (check)

$= -3.83 < 0$

Conclusion θ_{eq} is unstable equ.

$\theta_{eq} = .902$ rad.

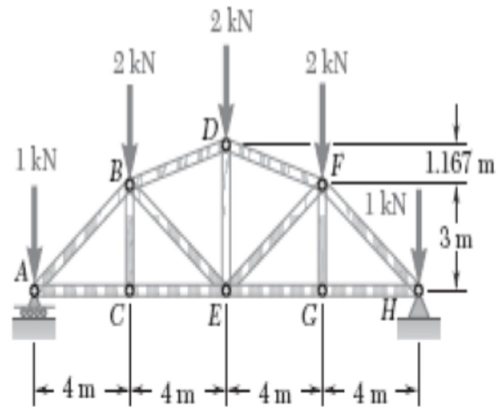
$$\left.\frac{d^2V}{d\theta^2}\right|_{\theta_{eq}=.902\text{ rad}}$$

$= 7.35$ (Check)

> 0

Conclusion: Stable equilibrium

Set 12 B: No submission required



PROBLEM 6.9

Determine the force in each member of the Gambrel roof truss shown. State whether each member is in tension or compression.

$\mathbf{F}_{AB} = 5$ kN C ◀

$\mathbf{F}_{AC} = 4$ kN T ◀

$F_{BD} = 4$ kN C ◀

$F_{BE} = 200$ N C ◀

$F_{CE} = 4$ kN T ◀

$F_{DF} = 4$ kN C ◀

$F_{DE} = 240$ N T ◀

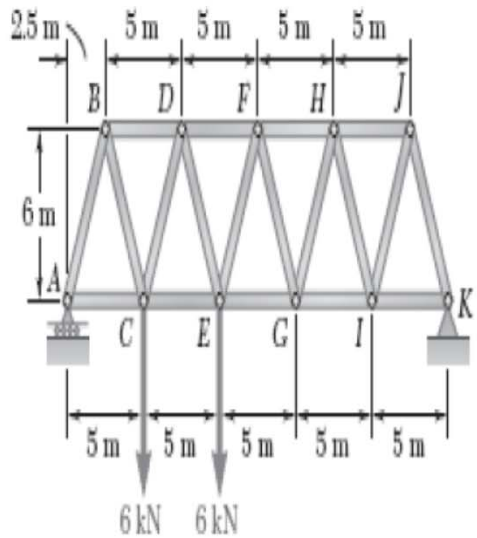
$F_{EF} = 200$ N C ◀

$F_{EG} = 4$ kN T ◀

$F_{FG} = 0$ ◀

$F_{FH} = 5$ kN C ◀

$F_{GH} = 4$ kN T ◀



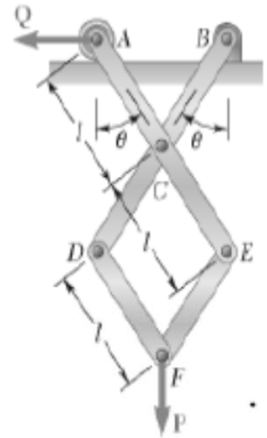
PROBLEM 6.45

A Warren bridge truss is loaded as shown. Determine the force in members *CE*, *DE*, and *DF*.

$F_{DF} = 9\text{ kN}$ C ◀

$F_{DE} = 2.6\text{ kN}$ T ◀

$F_{CE} = 8\text{ kN}$ T ◀

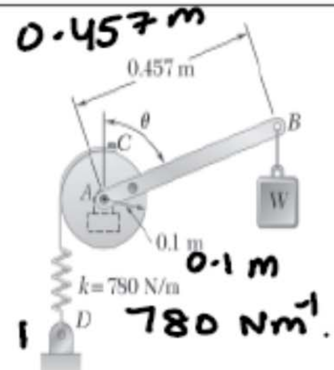


PROBLEM 10.14 Use PVW

The mechanism shown is acted upon by the force P; derive an expression for the magnitude of the force Q required to maintain equilibrium.

$$Q = \frac{3P\tan\theta}{2}$$

Weight of mechanism negligible



PROBLEM 10.76 Use PVW

A block of weight W is hung from member AB as shown. Neglecting the weight of AB and knowing that the spring is unstretched when $\theta = 20°$, determine the value of θ corresponding to equilibrium when $W = 6.6$ N. State whether the equilibrium is stable, unstable, or neutral.

Use PVW.

$\theta = 31.6°$ ◀

∴ Stable ◀