Announcements

- Last day of class: Monday, Dec. 10
- No discussion sections next week
- Last day of office hours and Piazza help: Wednesday, Dec. 12
- CBTF (last) Quiz 6 starts Thursday, Dec. 13

❑ Upcoming deadlines:

- Friday (12/7) – Today!
  - Written assignment 9
- Tuesday (12/11)
  - Last PL HW

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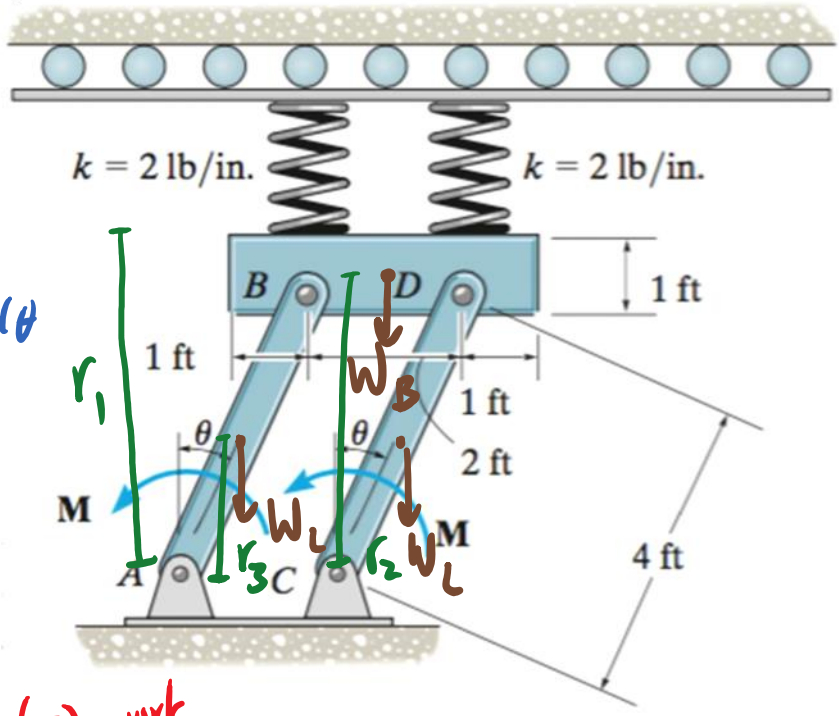
When $\theta = 20°$, the 50-lb uniform block compresses the two vertical springs 4 in. If the uniform links AB and CD each weigh 10 lb, determine the magnitude of the applied couple moments **M** needed to maintain equilibrium when $\theta = 20°$.



What that will do work ?

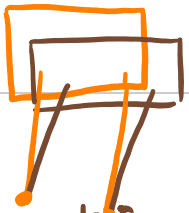
- F_{spring}, W_B, W_L, M

Virtual displacements:

- For F_{spring}: $dr_1 = 4\sin\theta\, d\theta$
- For W_B: $dr_2 = 4\sin\theta\, d\theta$
- For W_L: $dr_3 = 2\sin\theta\, d\theta$
- For M: $d\theta$

Work sign:

- F_{spring}, W_B & W_L will do (−) work
- M will do (+) work



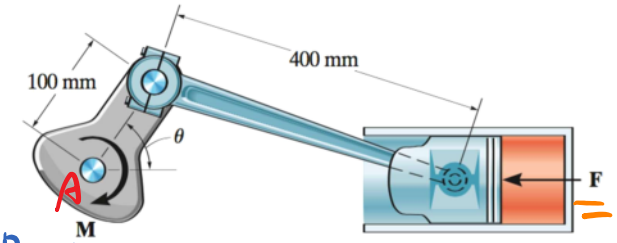
Virtual work eqn:

$$dU = 0 = 2dU_F + dU_{W_B} + 2dU_{W_L} + dU_M$$

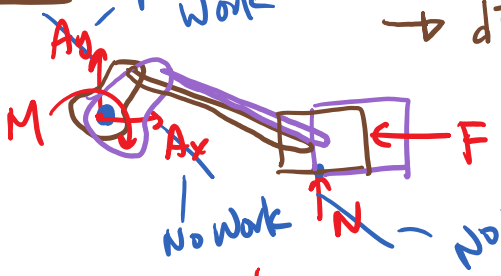
$$= -2k_s(4\sin\theta)d\theta - W_B(4\sin\theta)d\theta - 2W_L(2\sin\theta\, d\theta) + 2M d\theta$$

$$\rightarrow M = \frac{1}{2}\left(8k_s\sin\theta + 4W_B\sin\theta + 4W_L\sin\theta\right), \quad s = 4\text{ in.}$$

The crankshaft is subjected to a torque of M = 50 N m. Determine the horizontal compressive force F applied to the piston for equilibrium when $\theta = 60°$.



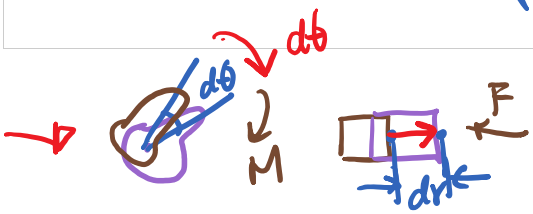
FBD

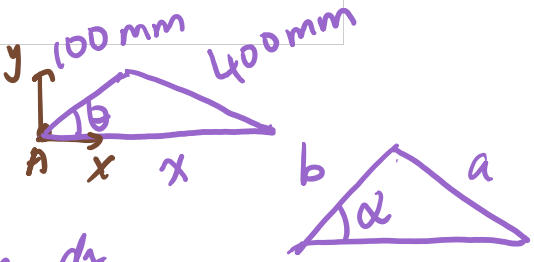


$\rightarrow dU = 0 = dU_M + dU_F = +M\,d\theta - F\left(\frac{x\sin\theta}{2x - 200\cos\theta}\right)d\theta$

$dU_M = M\,d\theta$

$dU_F = F\,dr$





- How to relate $d\theta$ with dx
  - ~ law of cosine: $a^2 = b^2 + c^2 - 2bc\cos\alpha$

$(400\text{ mm})^2 = (100\text{ mm})^2 + x^2 - 2(100\text{ mm})x\cos\theta$

Differentiate ↑

$0 = 0 + 2x\,dx - (200\text{ mm})\left[dx\cos\theta + (-\sin\theta\,d\theta)x\right]$

$\rightarrow (2x - 200\cos\theta)\,dx = x\sin\theta\,d\theta$.

$dx = \frac{x\sin\theta}{2x - 200\cos\theta}\,d\theta$

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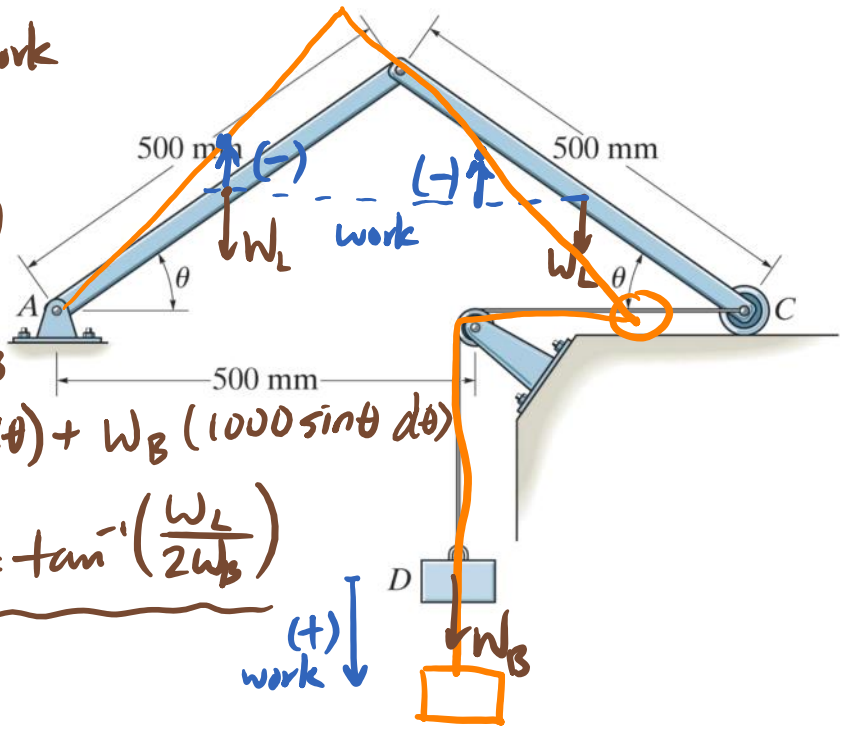
Determine the angel of equilibrium, θ, given that block D has a mass of 7 kg and the links each have a mass of 3 kg.



- Only W_L & W_B do work
- $dr_L = (250\,mm)\cos\theta\, d\theta$

  $dr_B = (1000\,mm)\sin\theta\, d\theta$

$dU = 0 = 2\,dU_L + dU_B$

$= -2W_L(250\cos\theta\, d\theta) + W_B(1000\sin\theta\, d\theta)$

$\frac{W_L}{2W_B} = \tan\theta \rightarrow \theta = \tan^{-1}\left(\frac{W_L}{2W_B}\right)$