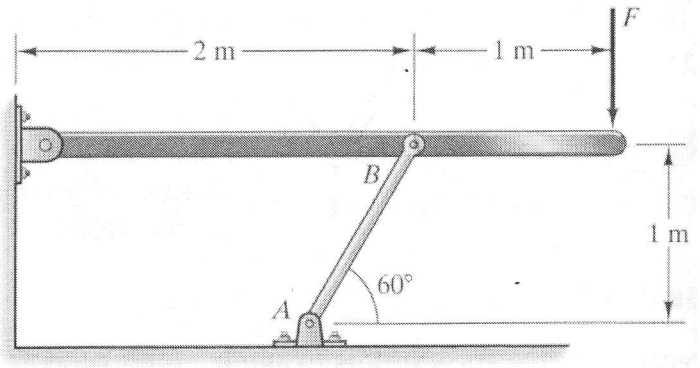
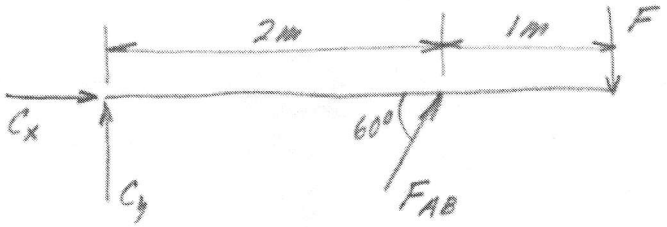
CME 260 – Mechanics of Materials
Exam #8 (04/30/2024)

StarID or TechID (no names) Grading

Do one of the two problems shown below (the second problem is on the back).
Show your work (you will not receive any credit if all you have is a final answer, right or wrong).

1. At what value of F will the bar AB buckle? Bar AB has a circular cross-section of radius 20 mm and its modulus of elasticity is E = 14 GPa.





$\sum M_C = 0, \quad -(3m)(F) + (2m)(F_{AB}\sin 60°) = 0$

$F = 0.57735\, F_{AB}$ (2 pts)

$P_{cr} = \dfrac{\pi^2 E I}{(KL)^2}$

$E = 14$ GPa

$I = \dfrac{\pi}{4}(0.020\,m)^4 = 1.2566\times10^{-7}\,m^4$ (2 pts)

K (pinned-pinned) $= 1$ (1 pt)

$L\sin 60° = 1\,m$ (2 pts)

$L = 1.1547\,m$

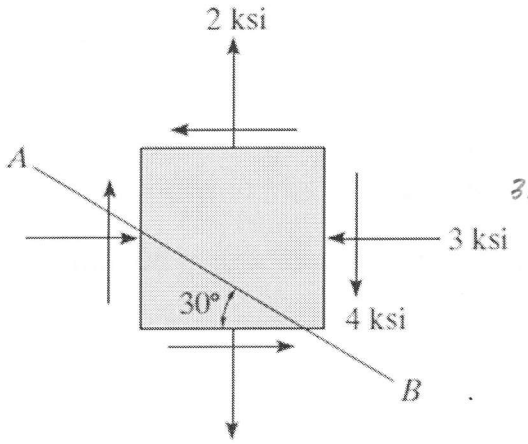
$$P_{cr} = \frac{\pi^2\left(14\times10^9\,\frac{N}{m^2}\right)(1.2566\times10^{-7}\,m^4)}{((1)(1.1547\,m))^2}$$

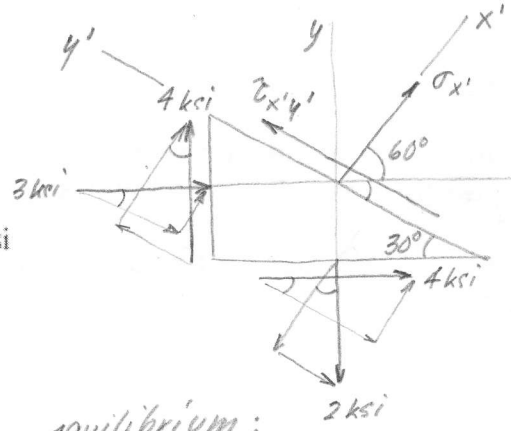
$= 13{,}022.6\,N$ (1 pt)

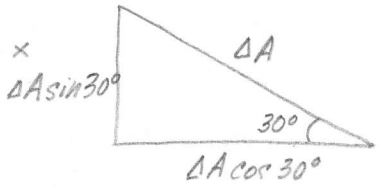
$F = 0.57735\,(13{,}022.6\,N)$

$= 7{,}518.6\,N$ or $\boxed{7.52\,kN}$ (2 pts)

2. Determine the stress components acting on plane AB.







equilibrium:

$\sum F_{x'} = 0,\ \sigma_{x'}\Delta A$
$+ 4\cos 30°\,\Delta A \sin 30° + 3\sin 30°\,\Delta A \sin 30°$
$- 2\cos 30°\,\Delta A \cos 30° + 4\sin 30°\,\Delta A \cos 30° = 0$

$\sigma_{x'} = -(4+4)\cos 30° \sin 30°$
$- 3\sin^2(30°)$
$+ 2\cos^2(30°)$
$= \boxed{-2.714 \text{ ksi}}$ (1)

$\sum F_{y'} = 0,\ \tau_{x'y'}\Delta A$
$+ 4\sin 30°\,\Delta A \sin 30° - 3\cos 30°\,\Delta A \sin 30°$
$- 2\sin 30°\,\Delta A \cos 30° - 4\cos 30°\,\Delta A \cos 30° = 0$

$\tau_{x'y'} = +(3+2)\cos 30° \sin 30°$
$- 4\sin^2(30°)$
$+ 4\cos^2(30°)$
$= \boxed{4.165 \text{ ksi}}$ (1)

(or) equations:

$\sigma_x = -3 \text{ ksi}$ (1.5)
$\sigma_y = 2 \text{ ksi}$ (1.5)
$\tau_{xy} = -4 \text{ ksi}$ (1.5)
$\theta = 60°$ (1.5)

$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$ (1)
$= \frac{(-3)+2}{2} + \frac{(-3)-2}{2}\cos 2(60°) + (-4)\sin 2(60°)$
$= \boxed{-2.714 \text{ ksi}}$ (1)

$\tau_{x'y'} = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$ (1)
$= -\frac{(-3)-2}{2}\sin 2(60°) + (-4)\cos 2(60°)$
$= \boxed{4.165 \text{ ksi}}$ (1)