STAEDTLER® No. 937 811E Engineer's Computation Pad

•••41 For the stepladder shown in Fig. 12-52, sides *AC* and *CE* are each 2.44 m long and hinged at *C*. Bar *BD* is a tie-rod 0.762 m long, halfway up. A man weighing 854 N climbs 1.80 m along the ladder. Assuming that the floor is frictionless and neglecting the mass of the ladder, find (a) the tension in the tie-rod and the magnitudes of the forces on the ladder from the floor at (b) *A* and (c) *E*. (*Hint:* Isolate parts of the ladder in applying the equilibrium conditions.)

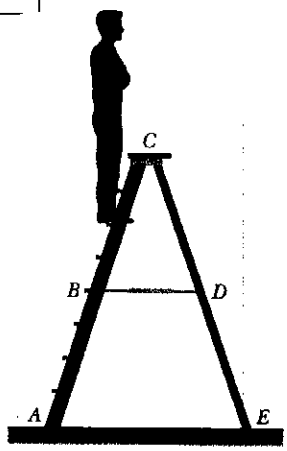
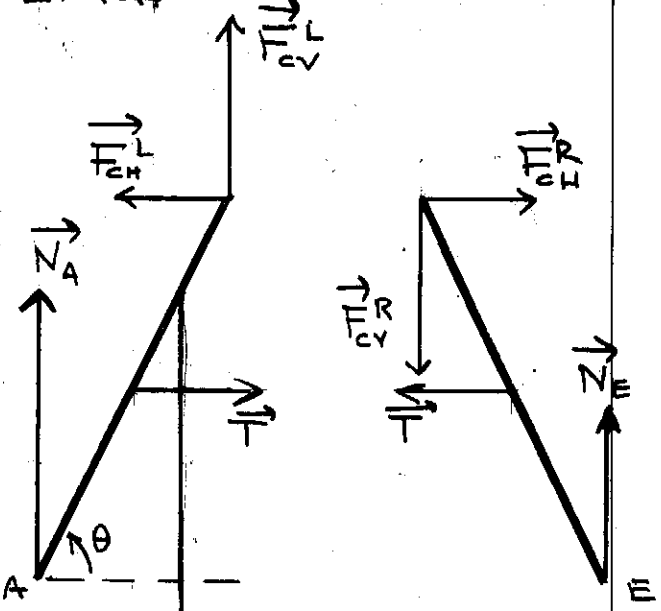


FIG. 12-52 Problem 41.

THE MAN BREAKS THE SYMMETRY OF THE LADDER MAKING FORCES DIFFER ON OPPOSITE SIDES.

DIVIDE THE LADDER DOWN ITS SYMMETRY AXIS AND CONSTRUCT FREE-BODY DIAGRAMS FOR EACH



L = LENGTH OF LADDER
TIE-ROD @ L/2
MAN @ f L from bottom
$\vec{F}^{\text{on Left by Right}}_{@C} = -\vec{F}^{\text{on Right by Left}}_{@C}$
WITH HORIZONTAL AN VERTICAL COMPONENT MAGNITUDES = F_{CH} & F_{CV}
ℓ = LENTH OF TIE-ROD
$\cos\theta = \frac{\ell/2}{L/2} = \frac{\ell}{L}$

11) $F^{\text{net}}_{\text{LEFT},x} = 0 \Rightarrow T - F_{CH} = 0$

12) $F^{\text{net}}_{\text{LEFT},y} = 0 \Rightarrow F_{CV} - mg + N_A = 0$

13) $F^{\text{net}}_{\text{RIGHT},x} = 0 \Rightarrow F_{CH} - T = 0$

14) $F^{\text{net}}_{\text{RIGHT},y} = 0 \Rightarrow N_E - F_{CV} = 0$

15) $\tau^{\text{net}}_{\text{LEFT ABOUT C}} = mg(1-f)L\cos\theta + T\frac{L}{2}\sin\theta - N_A L\cos\theta = 0$

$= mg(1-f)L\frac{\ell}{L} + T\frac{L}{2}\sqrt{1-(\ell/L)^2} - N_A L\frac{\ell}{L} = 0$

$\Rightarrow 2mg\ell(1-f) + T\sqrt{L^2-\ell^2} = 2N_A\ell$

16) $\tau^{\text{net}}_{\text{RIGHT ABOUT C}} = -T\frac{L}{2}\sin\theta + N_E L\cos\theta = 0$

$\Rightarrow 2N_E\ell = T\sqrt{L^2-\ell^2}$

14) $\Rightarrow F_{CV} = N_E = T\sqrt{L^2-\ell^2}/2\ell$

12) & 15) $T\sqrt{L^2-\ell^2}/2\ell - mg + [mg(1-f) + T\sqrt{L^2-\ell^2}/2\ell] = 0$

a) $T = mg(1-1+f)/\{\sqrt{L^2-\ell^2}/\ell\} = mg\ell f/\sqrt{L^2-\ell^2} = 211\text{ N}$

15) $N_A = mg(1-f) + (T = mg\ell f/\sqrt{L^2-\ell^2})\sqrt{L^2-\ell^2}/2\ell = mg(1-f+f/2)$

b) $N_A = mg(1-f/2) = mg(1-3/4/2) = 5mg/8 = 534\text{N}$

c) $N_E = (T = mg\ell f/\sqrt{L^2-\ell^2})\sqrt{L^2-\ell^2}/2\ell = mgf/2 = 3mg/8 = 320\text{N}$

$F_{CH} = T = mg\ell f/\sqrt{L^2-\ell^2} = 211\text{ N}$

$F_{CV} = mg - N_A = 3mg/8 = N_E \checkmark = 320\text{N}$