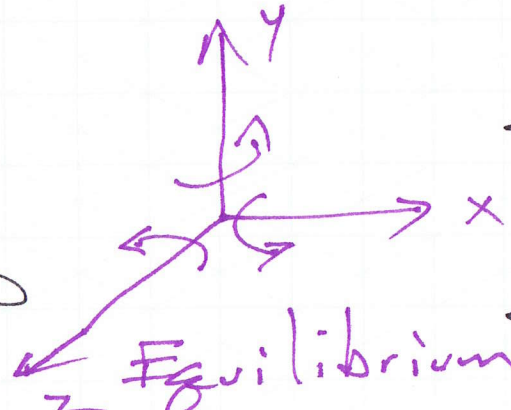


3-D Rigid Bodies

$$\sum \vec{F} = 0 \quad \text{and} \quad \sum \vec{M}_o = 0$$

Scalar Equations of Equilibrium

$\sum F_x = 0$		$\sum M_x = 0$
$\sum F_y = 0$		$\sum M_y = 0$
$\sum F_z = 0$		$\sum M_z = 0$

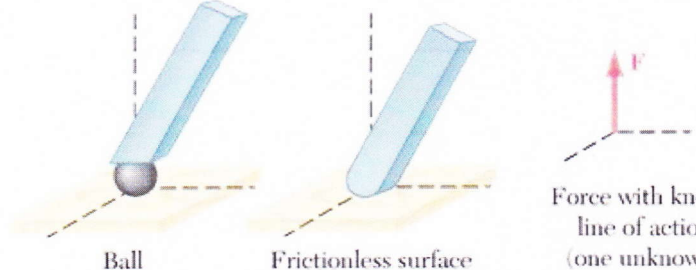
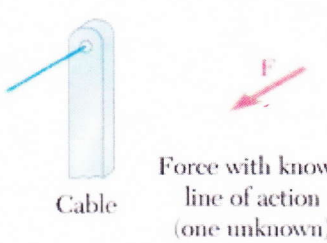
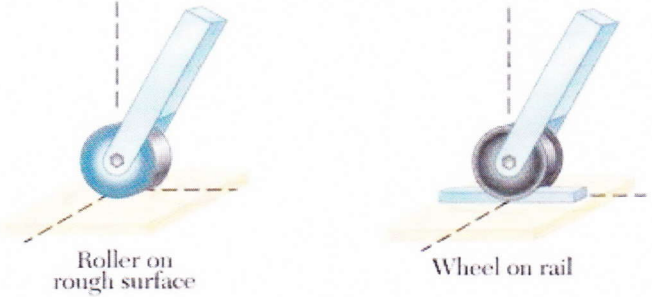

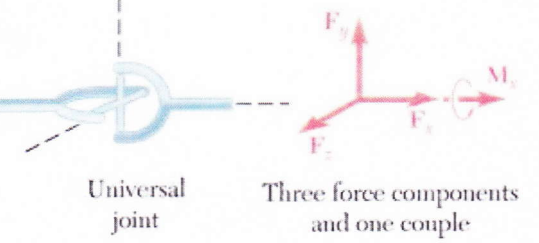
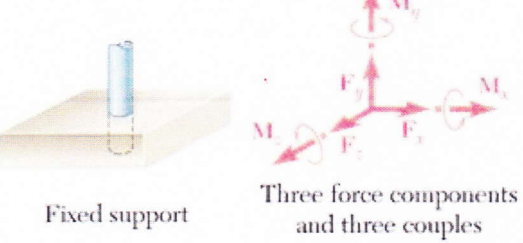
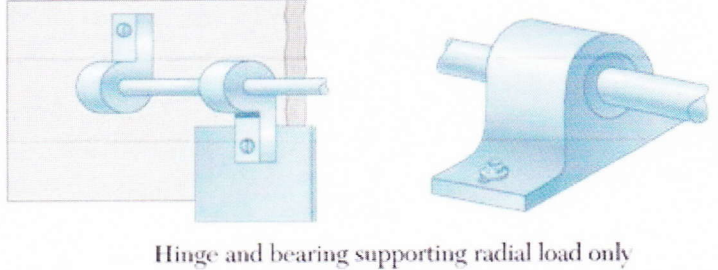
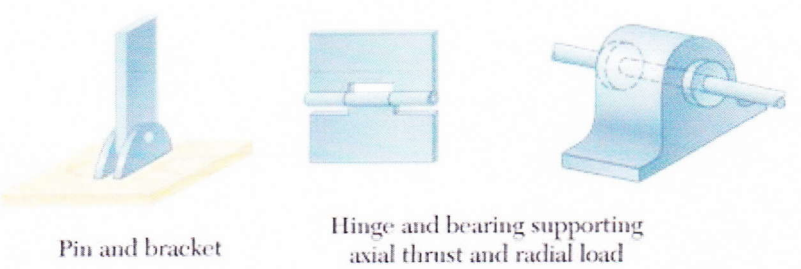
Equilibrium
Sign
Convention

$$\vec{r} \times \vec{F}$$

intuitively

Equilibrium of Rigid Bodies

2/11/11
2

 <p>Ball Frictionless surface</p> <p>Force with known line of action (one unknown)</p>	 <p>Cable</p> <p>Force with known line of action (one unknown)</p>
 <p>Roller on rough surface Wheel on rail</p> <p>Two force components</p>	
 <p>Rough surface Ball and socket</p> <p>Three force components</p>	
 <p>Universal joint</p> <p>Three force components and one couple</p>	 <p>Fixed support</p> <p>Three force components and three couples</p>
 <p>Hinge and bearing supporting radial load only</p> <p>Two force components (and two couples)</p>	
 <p>Pin and bracket Hinge and bearing supporting axial thrust and radial load</p> <p>Three force components (and two couples)</p>	

3-D Rigid Bodies

F.B.D. - indicate forces (Known and unknown)

Apply scalar Equations of Equilibrium

$$\sum F_x = 0$$

$$\sum M_x = 0$$

$$\sum F_y = 0$$

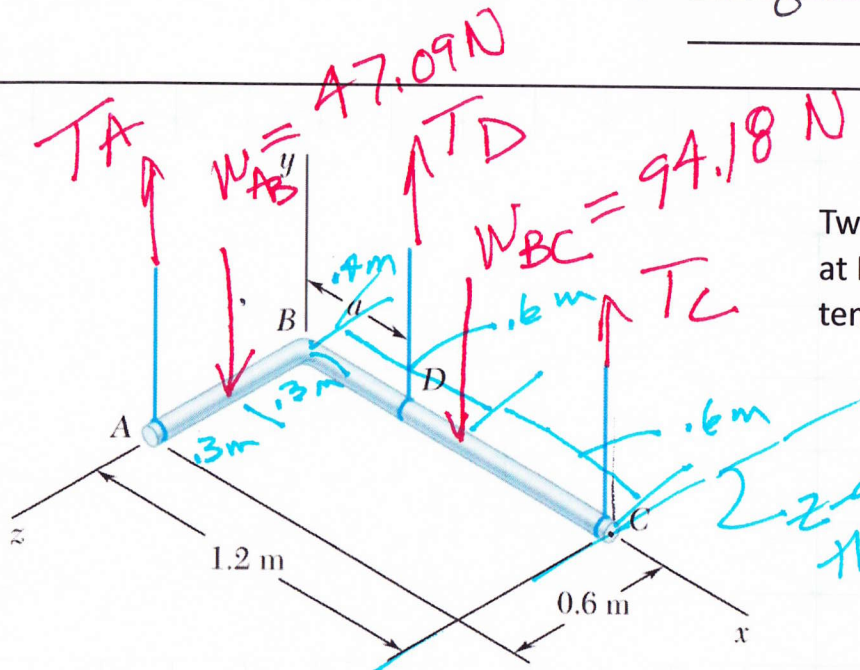
$$\sum M_y = 0$$

$$\sum F_z = 0$$

$$\sum M_z = 0$$

Sometimes
we might
Equations of
conditions

Solve for the unknowns.



Two steel pipes AB and BC, each having a mass per unit length of 8 kg/m are welded together at B and supported by three vertical wires as shown. Knowing that $a = 0.4 \text{ m}$, determine the tension in each wire.

$$(8 \text{ kg/m})(9.8 \text{ m/s}^2) = \underline{78.48 \text{ N/m}}$$

$$W_{BC} = 1.2(78.48) = \underline{94.18 \text{ N}}$$

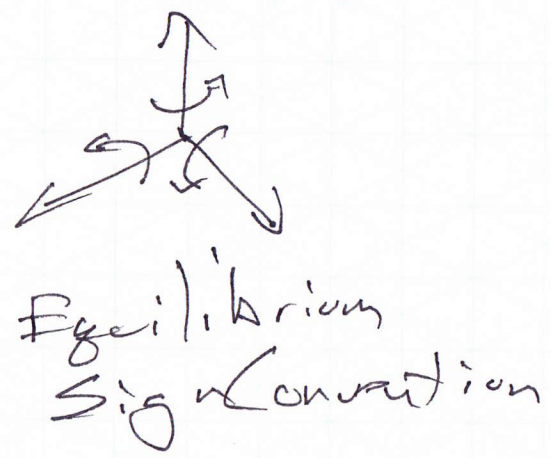
$$W_{AB} = .6(78.48) = \underline{47.09 \text{ N}}$$

1st observation

there are only 3 unknowns
 $3 < 6$ - unstable

but because of the way that this problem is loaded - we can say that it is conditionally stable - we only need 3 equations

F.B.D.



$$\sum F_z = 0 \quad - \text{useless}$$

$$\sum F_x = 0 \quad - \text{useless}$$

$$\sum M_y = 0 \quad - \text{useless}$$

$$\sum F_y = 0, \quad M_z = 0, \quad \sum M_x = 0$$

any axis
parallel to
the z axis

any axis
parallel to
the x axis

Intuitive Approach

$$\sum M_{x\text{-axis}} = 0$$

$$- T_A (.6) + (47.09)(.3) = 0$$

$$\underline{T_A = 23.55 \text{ N}} \quad \underline{\text{as shown}}$$

$\sum M_{z\text{-axis through } C} = 0$

23.55

$$-F_A(1.2) + 47.09(1.2) - T_D(.8) + 94.18(.6) = 0$$

$$.8 T_D = 84.76$$

$$\underline{T_D = 105.9 \text{ N} \quad \text{as shown}}$$

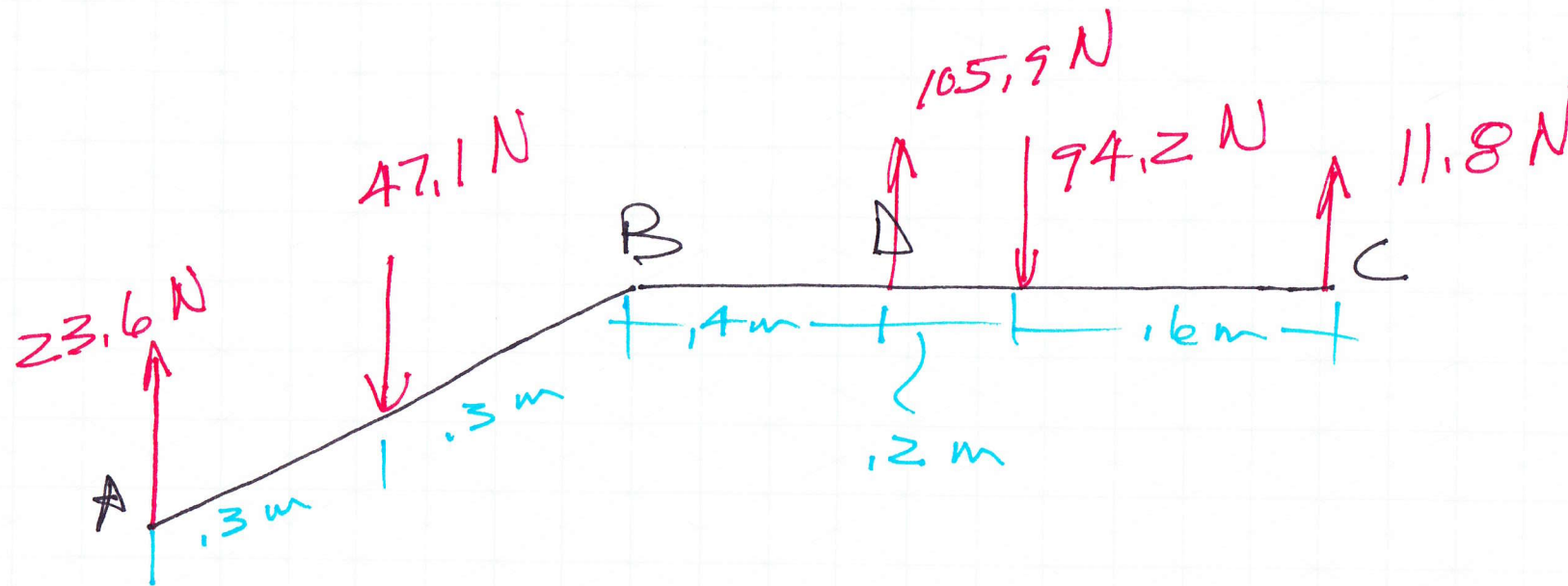
$$\uparrow \sum F_y = 0$$

23.55

$$T_A - 47.09 + T_D - 94.18 + T_C = 0$$

105.9

$$\underline{T_C = +11.82 \text{ N}} \quad \text{as shown}$$

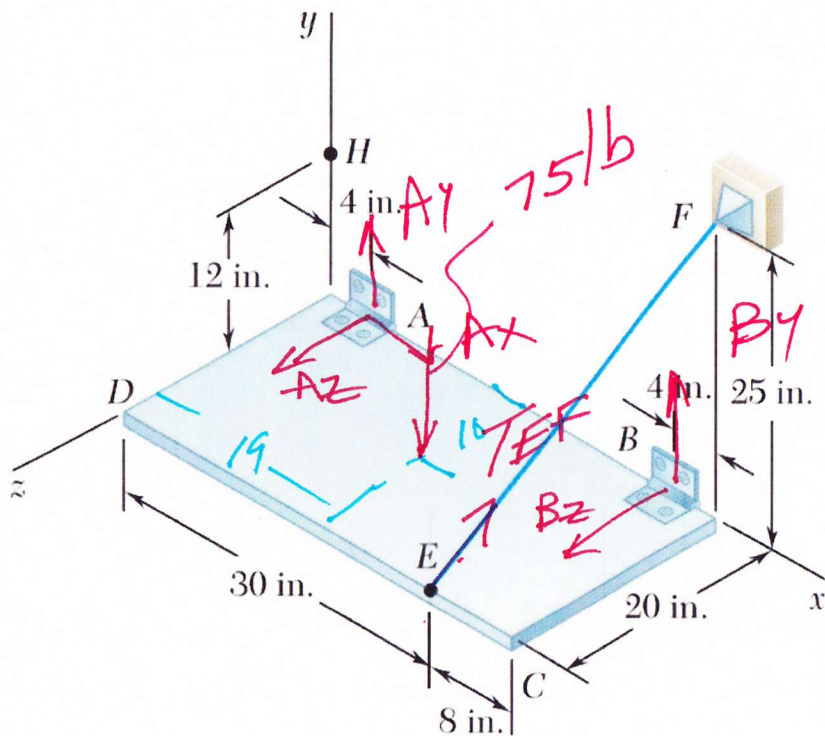


Summary of Results

The uniform rectangular plate shown weighs 75 lb and is held in place as shown with hinges at A and B and by cable EF. Assume that the hinges do not induce moment reactions and that the hinge at B does not resist axial thrust. Determine the tension in cable EF.

$A_x, A_y, A_z, B_y, B_z, T_{EF}$

6 unknowns — 6 equations
Stable — determinate



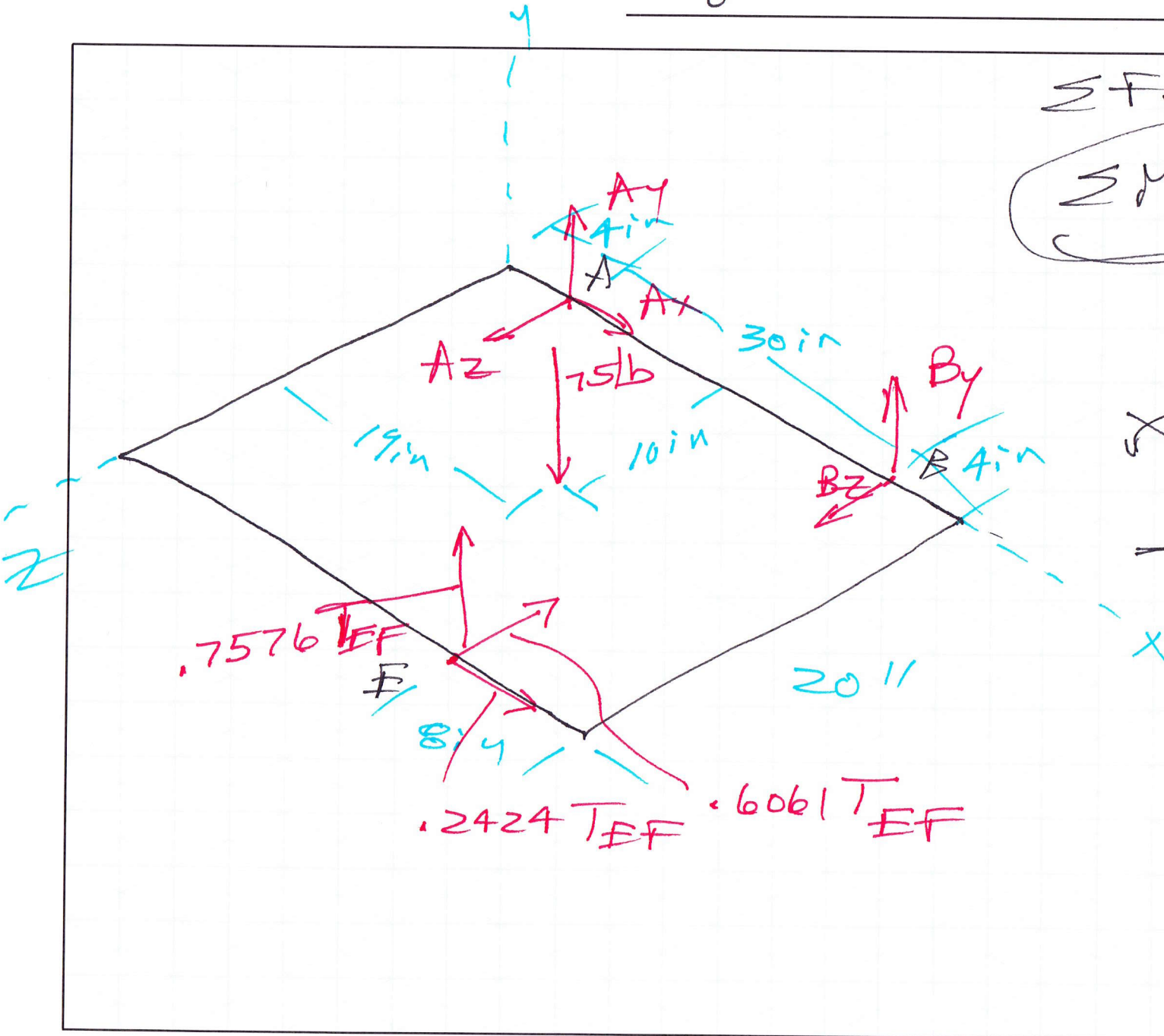
$$\vec{EF} = 0 \hat{i} + 25 \hat{j} - 20 \hat{k}$$

$$|\vec{EF}| = 33$$

$$\hat{n}_{EF} = \frac{0}{33} \hat{i} + \frac{25}{33} \hat{j} - \frac{20}{33} \hat{k}$$

$$\hat{n}_{EF} = .2424 \hat{i} + .7576 \hat{j} - .6061 \hat{k}$$

$$\vec{T}_{EF} = .2424 T_{EF} \hat{i} + .7576 T_{EF} \hat{j} - .6061 T_{EF} \hat{k}$$



$$\sum F_x = 0, \sum F_y = 0, \sum F_z = 0$$

$$\sum M_x = 0, \sum M_y = 0, \sum M_z = 0$$

Intuitive Approach

$$\sum M_x = 0$$

$$- (.7576 T_{EF})(20) + 75(10) = 0$$

$$\underline{T_{EF} = 49.5 \text{ lb}}$$