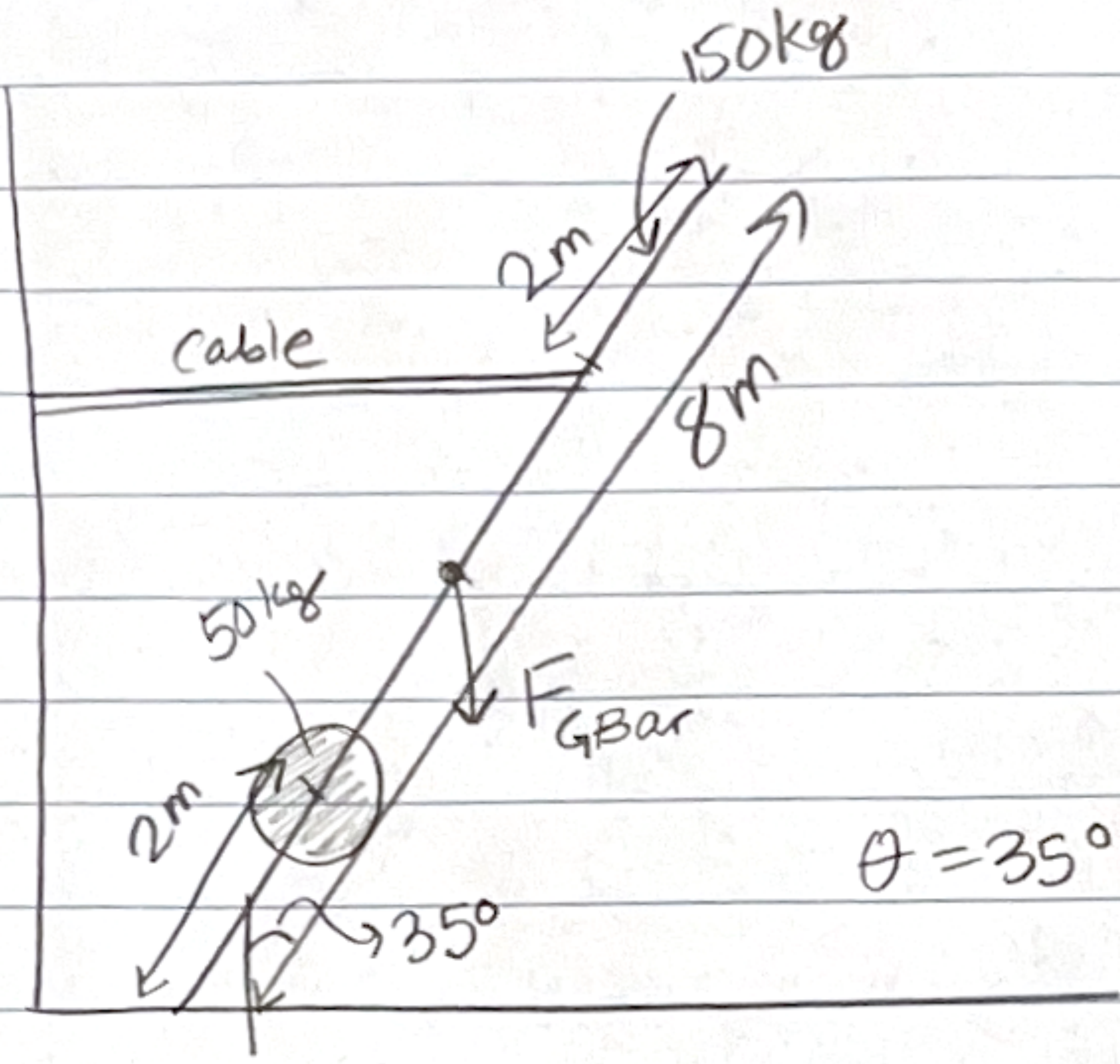
P. 333 #63

a)



$F_{GB} = m_B g = (150 kg)(9.8 N/kg) = 1470 N$

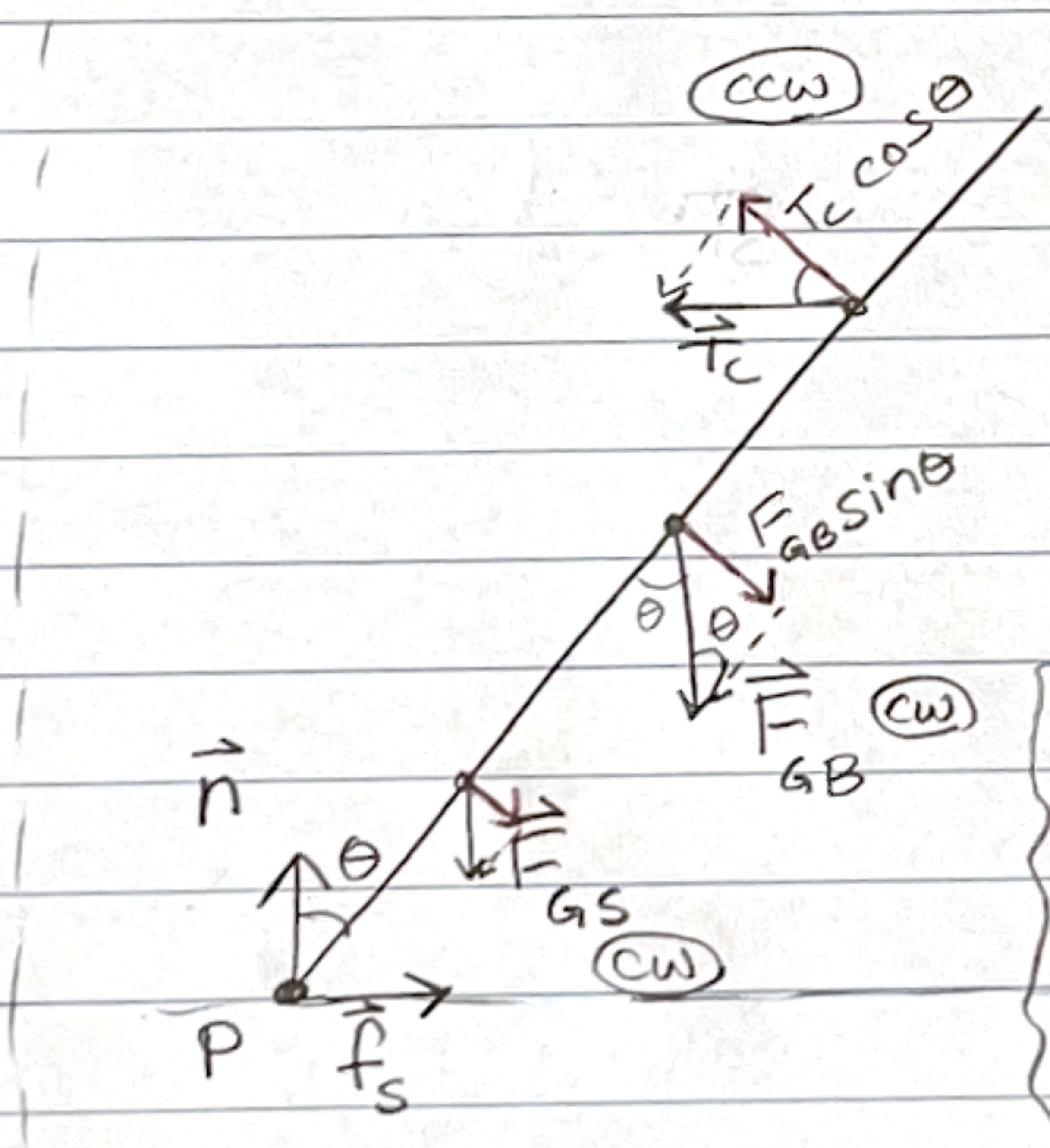
$F_{GS} = m_S g = (50 kg)(9.8 N/kg) = 490 N$

b) Simplify + Diagram

system: steel bar

object model: rigid body

motion model: at rest (static equilibrium)

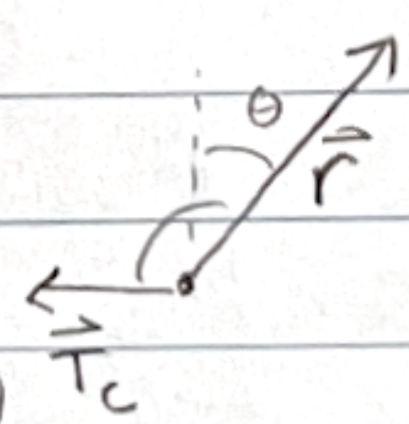


B = bar

S = sphere

T_c = tension in cable

φ For tension force:

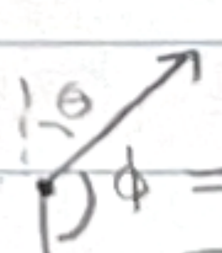


$\phi = 90 + \theta = 90° + 35° = 125°$

This can be used with $\tau = F \sin\phi$

or I could use the ⊥ components of the force, $\tau = r F_\perp$, shown in red on the FBD

For F_G forces, φ is



$\phi = 180 - \theta = 145°$

I will show the solution for 2 different ways of calculating the torque:

(1) $\boxed{\text{Using } \tau = rF\sin\phi}$

$$\Sigma\tau = -r_s F_{GS} \sin\phi_s - r_B F_{GB} \sin\phi_B + r_T T_c \sin\phi_T = 0$$

$$-(2m)(490N)\sin(145°) - (4m)(1470N)\sin(145°) + (6m)(T_c)\sin(125°) = 0$$

$$-562.10 - 3372.63 + 4.91 T_c = 0$$

$$-3934.73 = -4.91 T_c$$

$$\boxed{801N = T_c}$$

(e) 801 N seems reasonable for the tension in a cable supporting a 150kg sculpture

(2) $\boxed{\text{using the } \perp \text{ component of the forces, } \tau = rF_\perp}$

$$\Sigma\tau = -r_s (F_{GS})_\perp - r_B (F_{GB})_\perp + r_T (T_c)_\perp = 0$$

$$= -(2m)(F_{GS}\sin\theta) - (4m)(F_{GB}\sin\theta) + r_T (T_c\cos\theta) = 0$$

$$= -(2)(490N)\sin 35° - (4)(1470N)\sin 35° + (6m)(T_c)\cos 35° = 0$$

$$-562.10 - 3372.63 + 4.91 T_c = 0$$

$$-3934.73 = -4.91 T_c$$

$$\boxed{801N = T_c}$$

normal force exerted by the ground:

$\Sigma F_y = 0$ There are 3 vertical forces

$n - F_{GS} - F_{GB} = 0$

$n = F_{GS} + F_{GB}$

$n = 490N + 1470N$

$\boxed{n = 1960N, \text{ up}}$

friction force

$\Sigma F_x = 0$ There are 2 horizontal forces

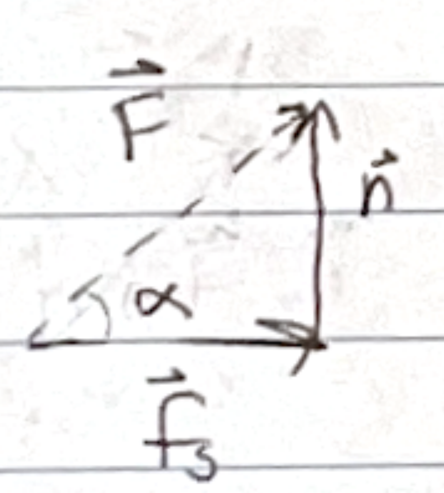
$f_s - T_c = 0$

$f_s = T_c$

$\boxed{f_s = 801N, \text{ right}}$

Total force exerted by the ground:

The ground exerts the friction force and the normal force, so I need to add those vectors together:



Find magnitude

$f_s^2 + n^2 = F^2$

$(801N)^2 + (1960N)^2 = F^2$

$2117N = F$

Find angle

$\tan\alpha = \frac{n}{f_s}$

$\tan\alpha = \frac{1960N}{801N}$

$\alpha = 68°$

The ground exerts a force of 2117 N at an angle of 68° above the horizontal.