

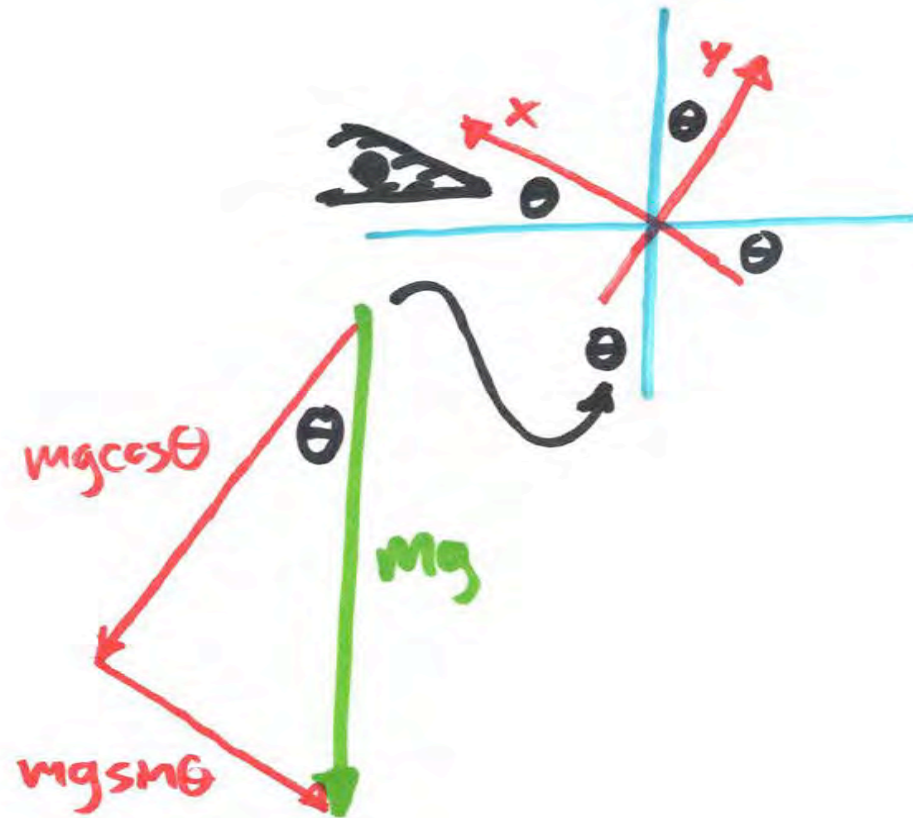
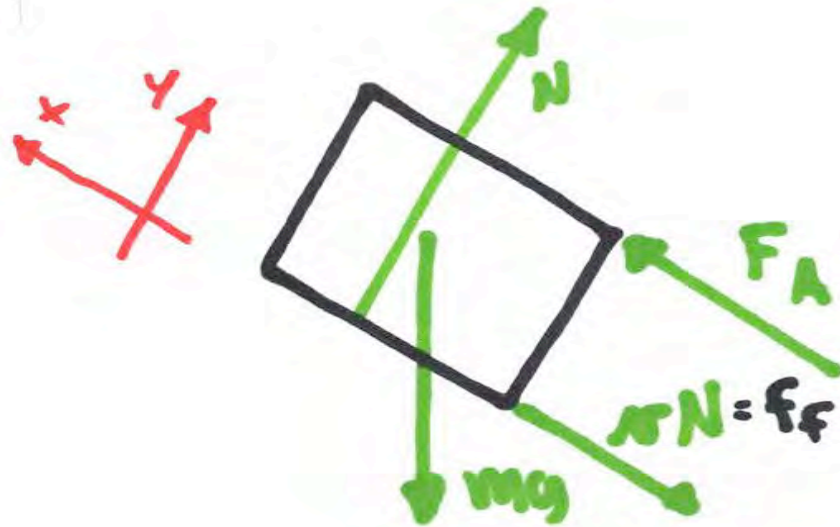
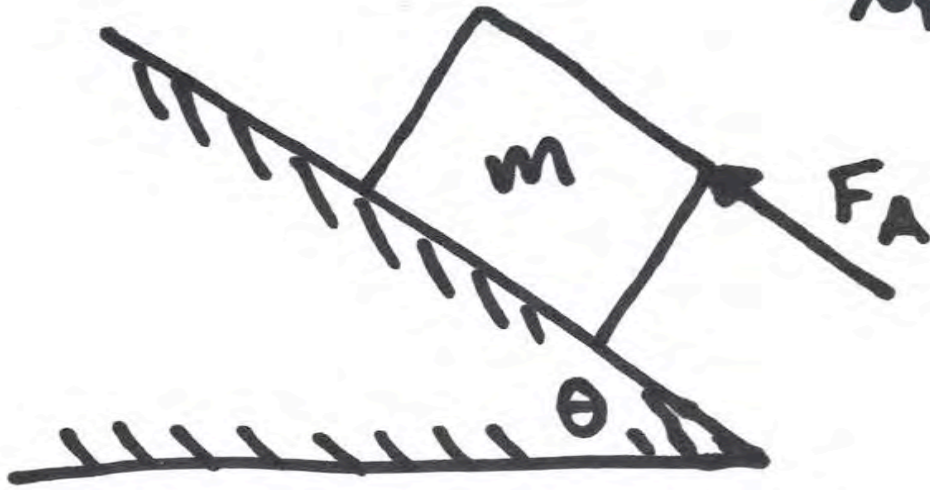
What force is needed to make it slide up?

$$\mu_s = 0.3$$

$$\theta = 20^\circ$$

$$\mu_k = 0.2$$

$$m = 100 \text{ kg}$$



set to zero

$$\Sigma F_x = \cancel{ma_x} = \underline{F_A} - \mu \underline{N} - mg \sin \theta \quad (1)$$

$$\Sigma F_y = \cancel{ma_y}^0 = \underline{N} - mg \cos \theta \quad (2)$$

solve (2) for N in (2)

$$N = mg \cos \theta$$

(2a)

sub (2a) into (1)

$$0 = F_A - \mu [mg \cos \theta] - mg \sin \theta$$

$$\boxed{F_A = mg (\sin \theta + \mu \cos \theta)}$$

$$F_A = (100)(9.81)(\sin 20 + 0.3 \cos 20)$$

$$\boxed{F_A = 612 \text{ N}}$$

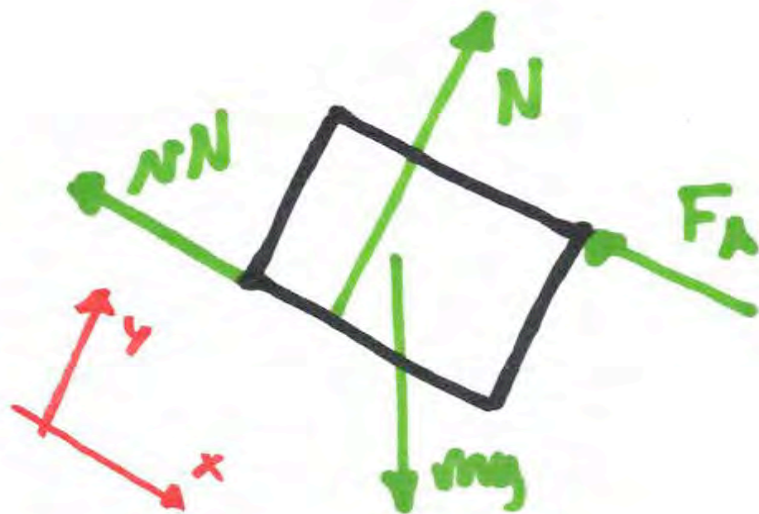
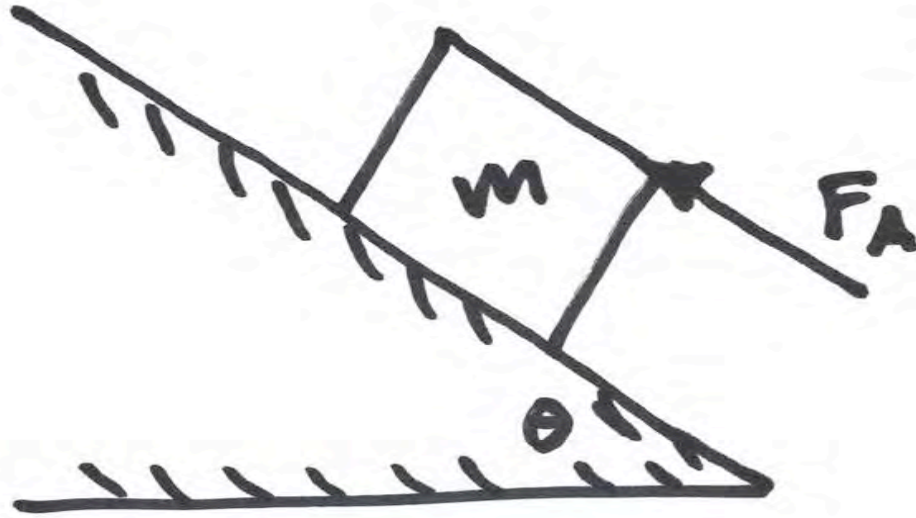
What is the minimum force needed so it doesn't slide down?

$$\mu_s = 0.3$$

$$\theta = 20^\circ$$

$$\mu_k = 0.2$$

$$m = 100 \text{ kg}$$



$$\Sigma F_x = \cancel{m a_x}^{\text{set to zero}} = mg \sin \theta - \mu \underline{N} - \underline{F_A} \quad (1)$$

$$\Sigma F_y = \cancel{m a_y}^0 = \underline{N} - mg \cos \theta \quad (2)$$

solve (2) for N:

$$N = mg \cos \theta$$

(2a)

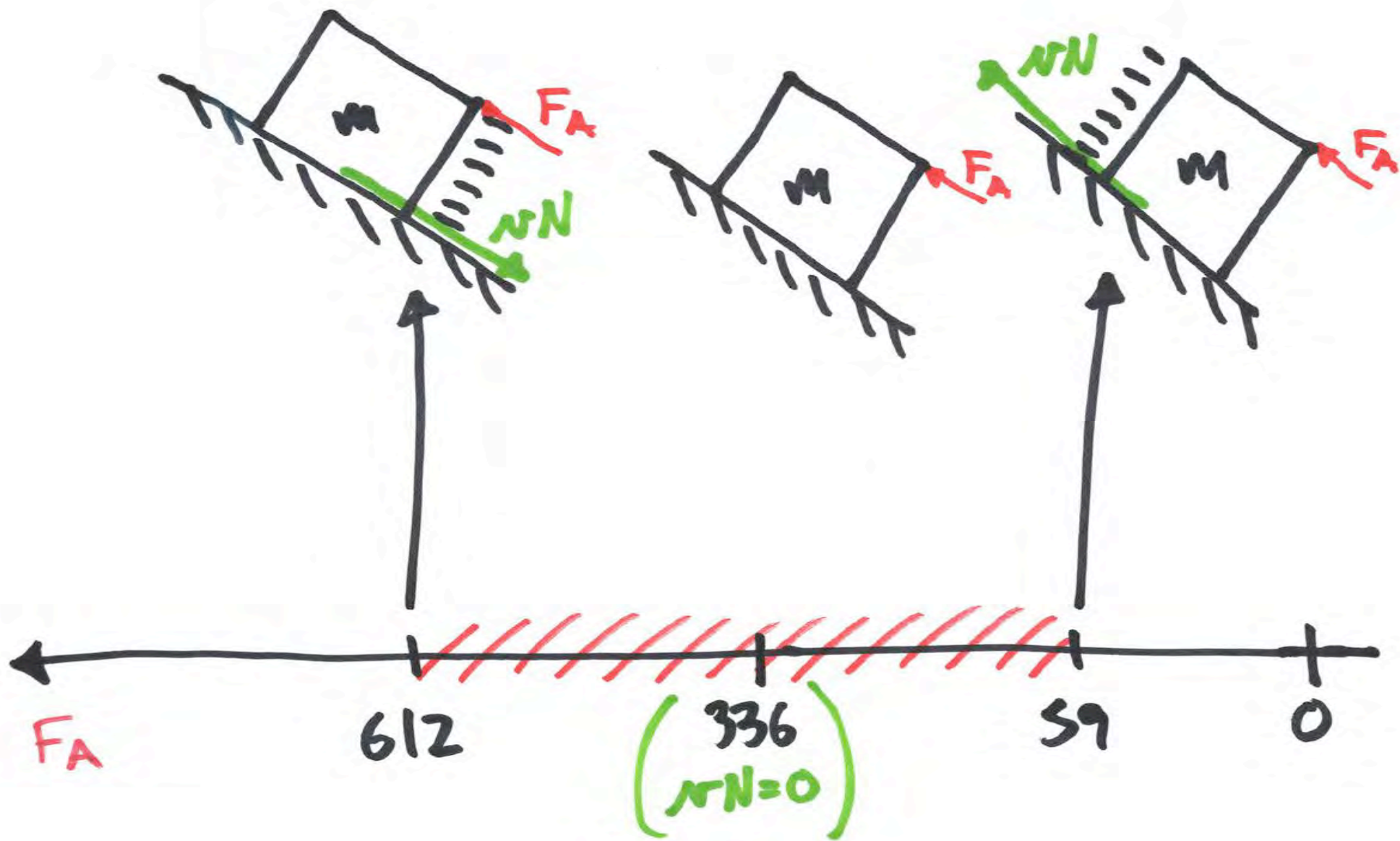
sub (2a) into (1)

$$0 = mg \sin \theta - \mu [mg \cos \theta] - F_A$$

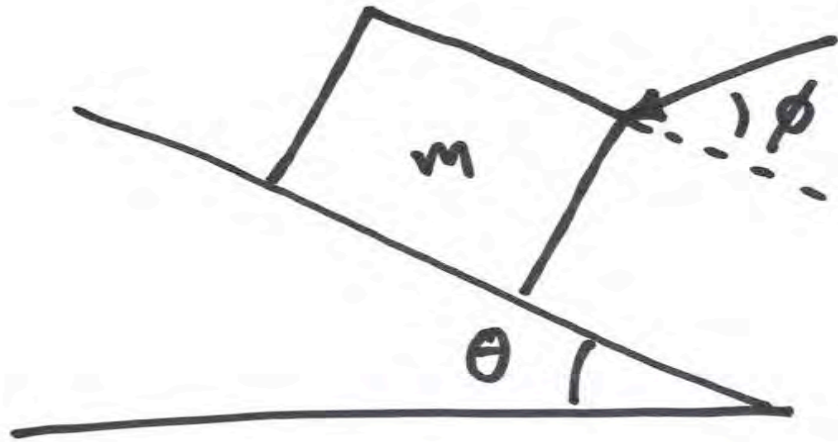
$$F_A = mg (\sin \theta - \mu \cos \theta)$$

$$F_A = (100)(9.81)(\sin 20 - 0.3 \cos 20)$$

$$F_A = 59 \text{ N}$$



Determine force range in which the object doesn't move.



$$m = 100 \text{ kg}$$

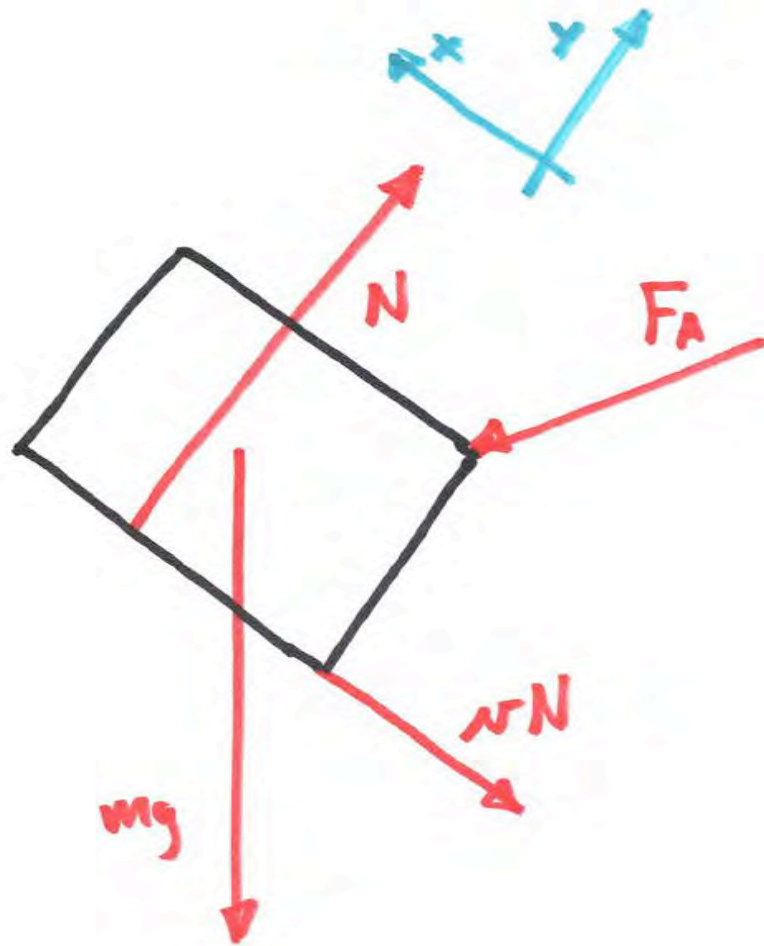
$$\theta = 25^\circ$$

$$\phi = 35^\circ$$

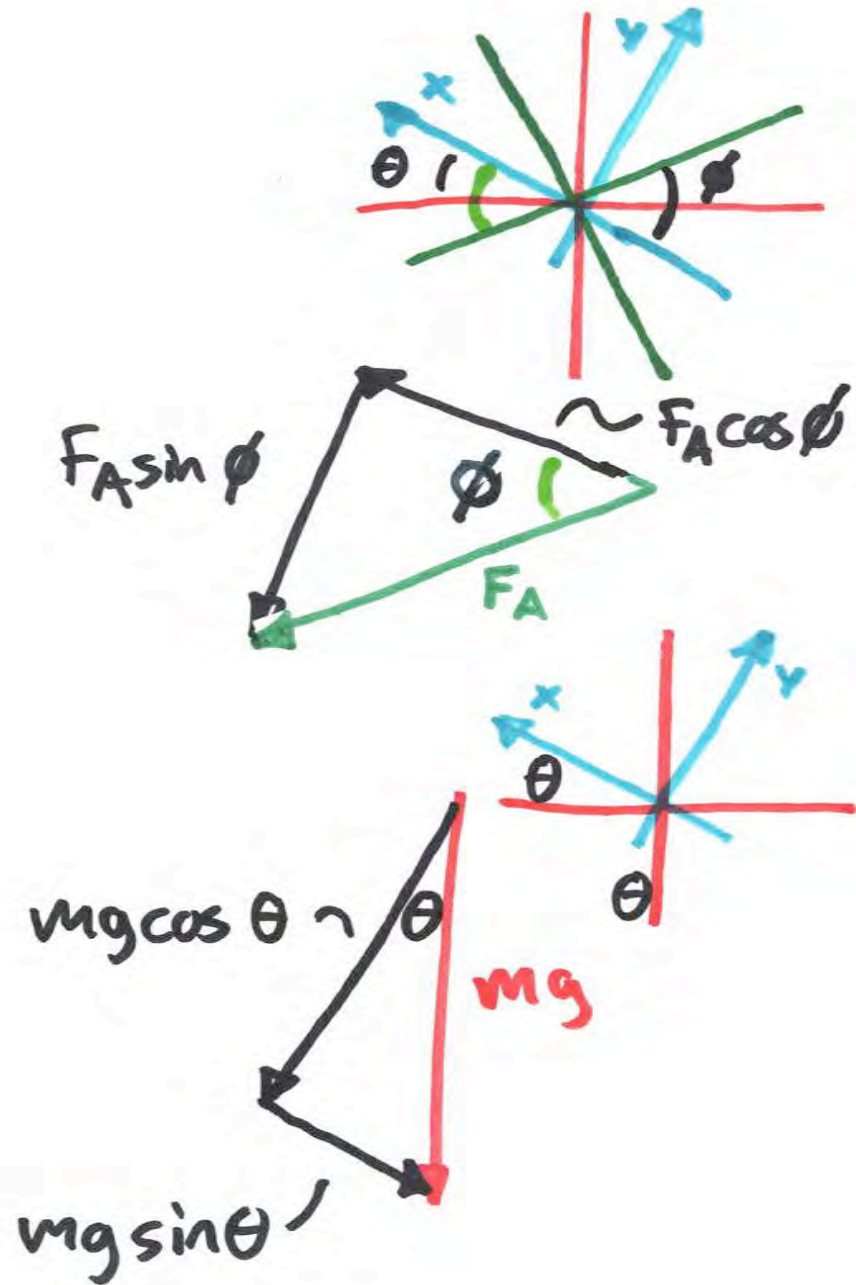
$$\mu_s = 0.3$$

$$\mu_k = 0.2$$

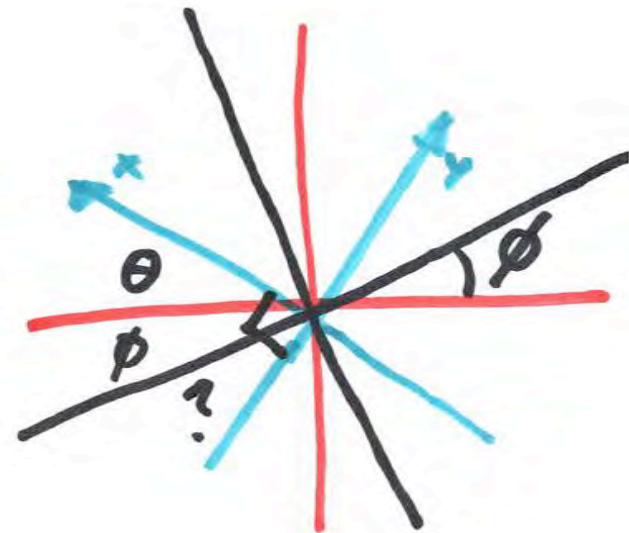
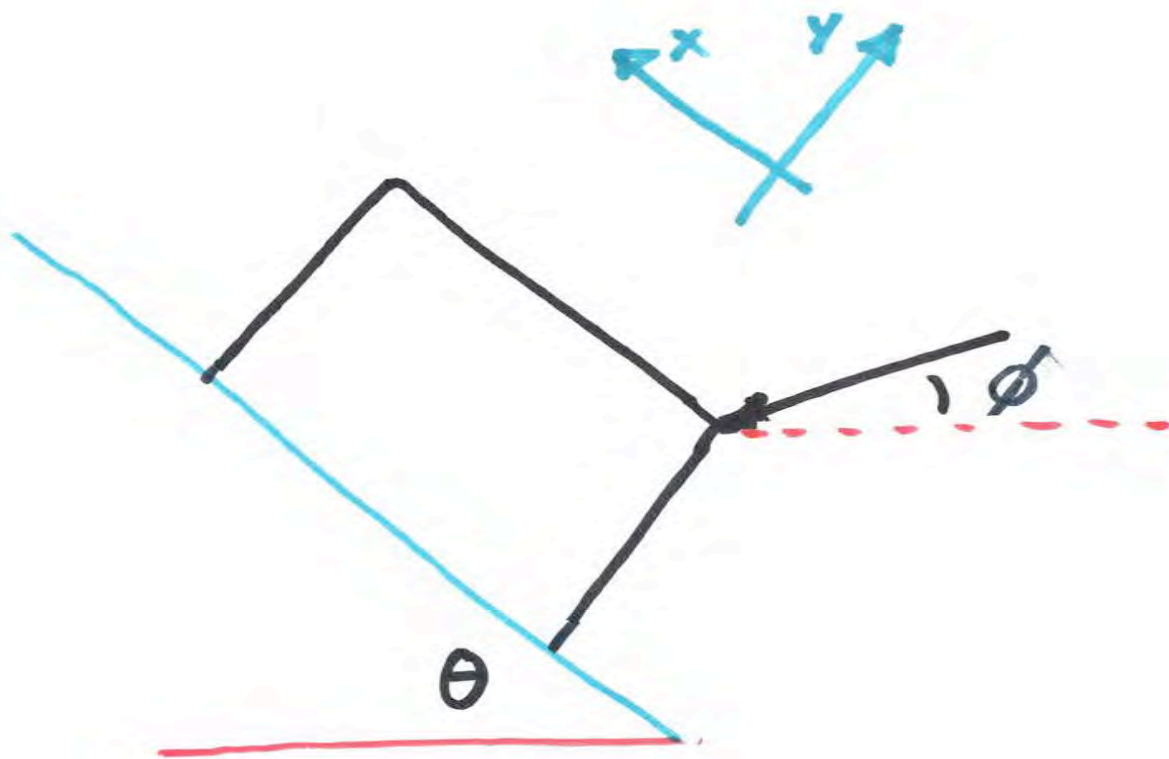
FBD:



(sliding up)



Aside:



$$\phi = 90^\circ - \theta - \phi$$

Newton's 2nd Law:

$\Sigma F_x = m \underline{a_x} = \underline{F_A} \cos \phi - mg \sin \theta - \mu \underline{N} \quad (1)$

Annotations: A green arrow points from "set $a_x = 0$ " to $\underline{a_x}$. A blue arrow points from $\underline{a_y}$ to $\underline{N}$ in the next equation.

$\Sigma F_y = m \underline{a_y} = \underline{N} - mg \cos \theta - \underline{F_A} \sin \phi \quad (2)$

Solve (2) for N:

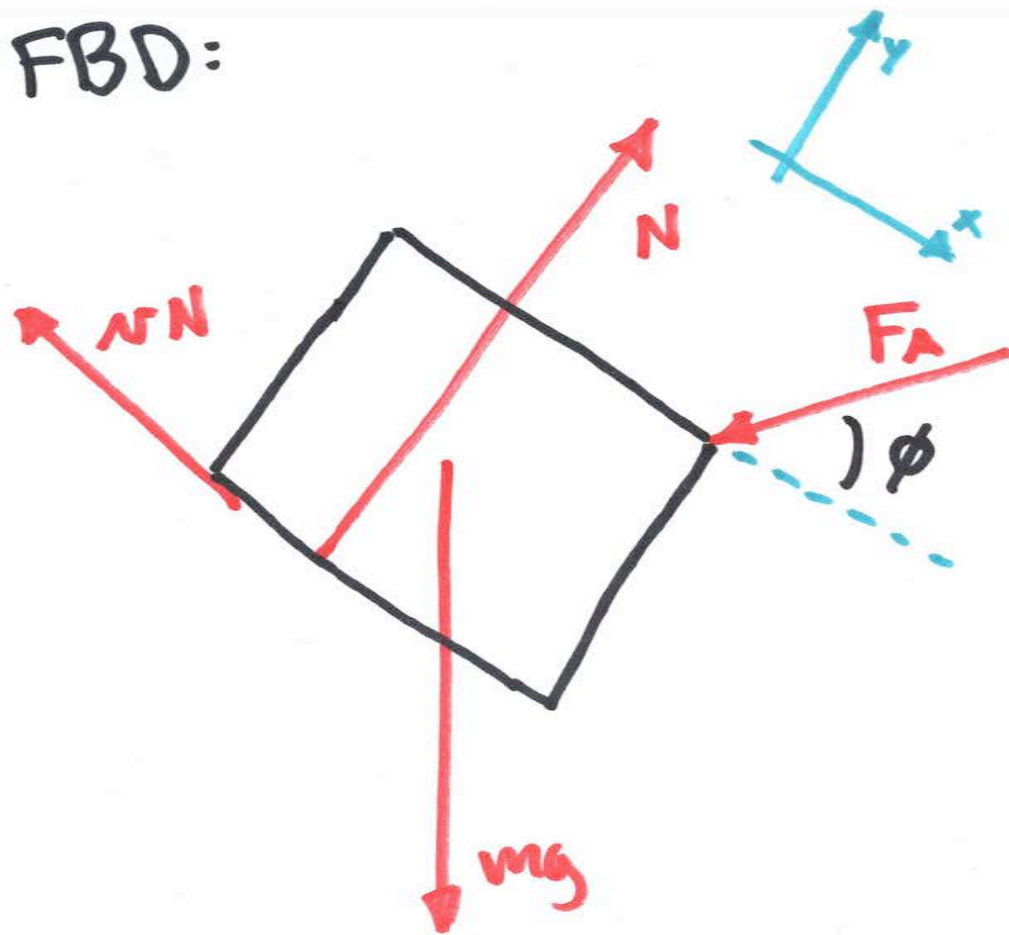
$$N = mg \cos \theta + F_A \sin \phi \quad (2a)$$

sub. (2a) into (1)

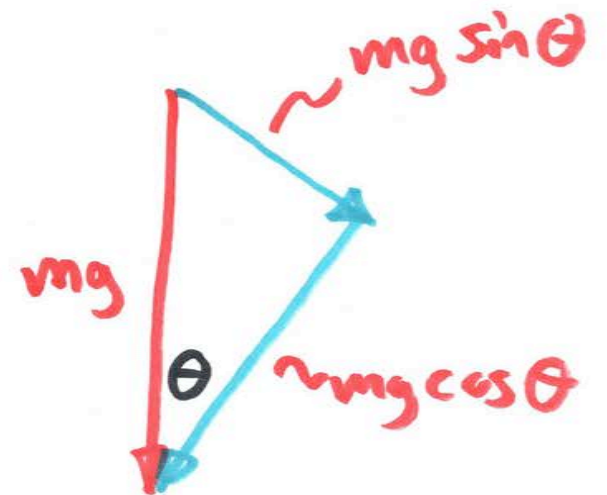
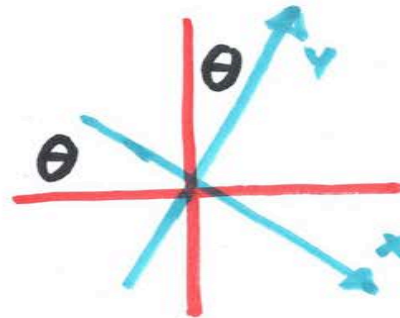
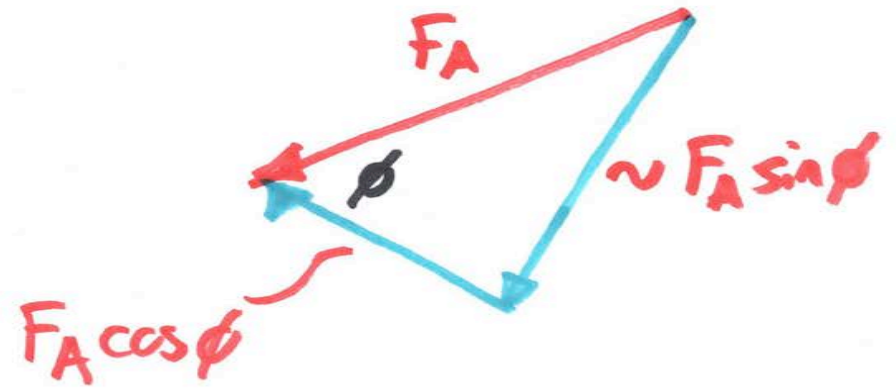
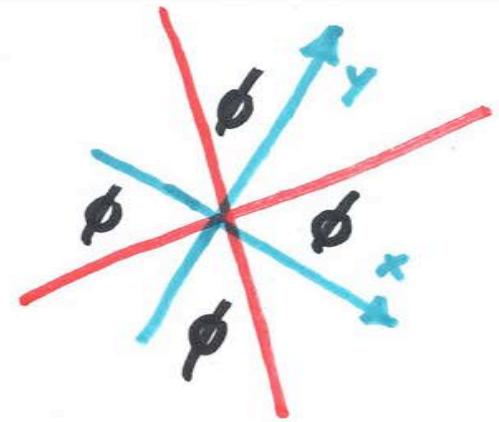
$$0 = F_A \cos \phi - mg \sin \theta - \mu [mg \cos \theta + F_A \sin \phi]$$

$$F_A = mg \frac{\sin \theta + \mu \cos \theta}{\cos \phi - \mu \sin \phi}$$

FBD:



(sliding down)



Newton's 2nd Law:

$\Sigma F_x = \cancel{m a_x} = mg \sin \theta - \underline{F_A} \cos \phi - \underline{\mu N}$ (1)

$\Sigma F_y = \cancel{m a_y} = \underline{N} - mg \cos \theta - \underline{F_A} \sin \phi$ (2)

solve (2) for N:

$$N = mg \cos \theta + F_A \sin \phi \quad (2a)$$

sub (2a) into (1)

$$0 = mg \sin \theta - F_A \cos \phi - \mu [mg \cos \theta + F_A \sin \phi]$$

$$F_A = mg \frac{\sin \theta - \mu \cos \theta}{\mu \sin \phi + \cos \phi}$$

$$F_A = (100)(9.81) \frac{\sin 25^\circ + (0.3)(\cos 25^\circ)}{\cos 35^\circ - (0.3)(\sin 35^\circ)} = 1053 \text{ N}$$

$$F_A = (100)(9.81) \frac{\sin (25^\circ) - 0.3 \cos 25^\circ}{(0.3) \sin 35^\circ + \cos (35^\circ)} = 149 \text{ N}$$

