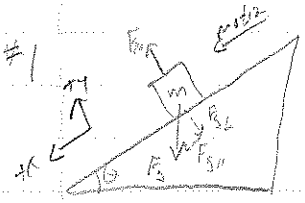
# Introduction to Inclined Planes

#1




$m = 20.\ kg$ $\quad \vec{g} = 9.81\ m/s^2$ [down]

$\theta = 25°$ $\quad \vec{a}_y = 0\ m/s^2$

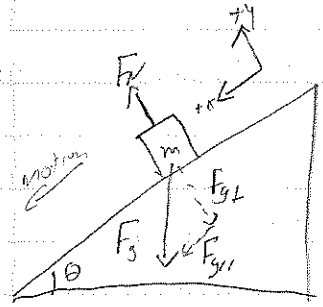
$\vec{a}_x = ?$

$$F_{Net,x} = F_{g\parallel} = ma_x \rightarrow mg\sin(\theta) = ma_x$$

$$\therefore a_x = g\sin(\theta) = (9.81\ m/s^2)\sin(25°)$$
$$= 4.14589\ m/s^2$$

$$\boxed{\vec{a}_x = 4.15\ m/s^2\ [\text{down ramp}]}$$

#2




$m = 30.\ kg$

$\theta = 30°$

$\vec{a}_y = 0\ m/s^2$

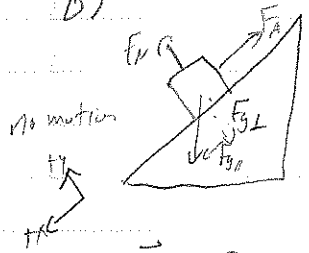
$\vec{g} = 9.81\ m/s^2$

$\vec{a}_x = ?$

a) $F_{Net,x} = F_{g\parallel} = ma_x \rightarrow mg\sin\theta = ma_x$

$\therefore a_x = g\sin(\theta) = (9.81\ m/s^2)\sin(30°) = 4.905\ m/s^2 = \boxed{4.91\ m/s^2}$

b)




$\vec{a}_x = 0\ m/s^2$

$F_{Net,x} = F_{g\parallel} - F_A = 0\ N$

$F_A = F_{g\parallel} = mg\sin\theta$

$= (30.\ N)(4.91\ m/s^2)$

$= 147.15\ N = \boxed{150\ N}$

#2c) $\vec{F}_A = 50.\ N$ [up ramp]

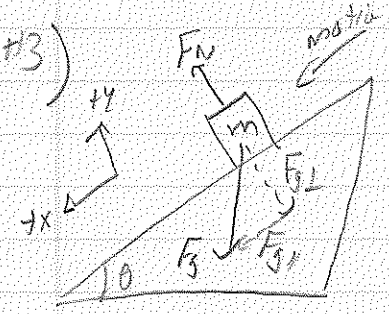
$F_{Net,x} = F_{g//} - F_A = ma_x$

$$a_x = \frac{F_{g//} - F_A}{m} = \frac{mg\sin\theta - F_A}{m} = \frac{(30.\ kg)(9.81\ m/s^2)\sin(30^\circ) - (50.\ N)}{(30.\ kg)}$$

$$a_x = \frac{97.15\ N}{30.\ kg} = 3.238\ m/s^2$$

$\vec{a}_x = 3\ m/s^2$ [down ramp]

#3)




$\theta = 15^\circ$
$\vec{a}_x = ?$
$\vec{a}_y = 0\ m/s^2$
$\vec{g} = 9.81\ m/s^2$ [down]

$F_{Net,x} = F_{g//} = ma_x$

$mg\sin\theta = ma_x$

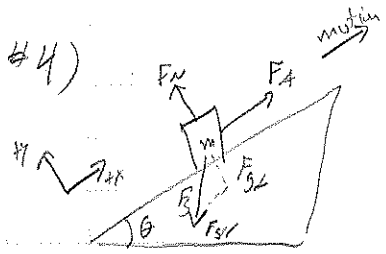
$a_x = g\sin(\theta) = (9.81\ m/s^2)\sin(15^\circ)$
$= 2.5390\ m/s^2$

$\vec{a}_x = 2.54\ m/s^2$ [down ramp]

b) With no friction, $\vec{a}_x$ is not dependent on $m$

# Introduction to Inclined Plane

#4)




$\vec{F}_g = 200.\,N$ [down]
$\theta = 25°$
$\vec{F}_A = 125\ N$ [up ramp]
$\vec{a}_y = 0\ m/s^2$

$\vec{g} = 9.81\ m/s^2$
$\vec{a}_x = ?$

$F_g = mg \rightarrow m = \frac{F_g}{g}$

$F_{net,x} = F_A - F_{g\parallel} = ma_x$

$a_x = \frac{F_A}{m} - \frac{F_{g\parallel}}{m} = \frac{F_A}{(F_g/g)} - \frac{F_g \sin(\theta)}{(F_g/g)}$

$a_x = g\left(\frac{F_A}{F_g}\right) - g\sin(\theta) = g\left(\left(\frac{F_A}{F_g}\right) - \sin(\theta)\right)$

$= (9.81 m/s^2)\left(\frac{125N}{200N} - \sin(25°)\right) = 1.98536\ m/s^2$

$\boxed{\vec{a}_x = 1.99\ m/s^2 \text{ [up ramp]}}$

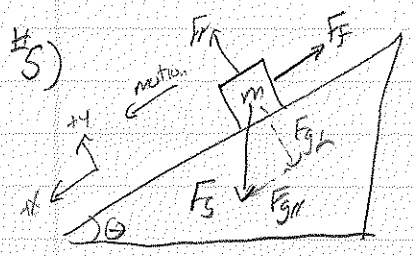
OR $m = \frac{F_g}{g} = \frac{200.N}{9.81 m/s^2} = 20.387\ kg$

$a_x = \frac{F_A - F_g \sin\theta}{m} = \frac{(125N) - (200N)\sin 25°}{(20.387\ kg)} = \frac{40.476\ N}{20.387\ kg}$

$= 1.98536 m/s^2$

$\boxed{\vec{a}_x = 2.0\ m/s^2 \text{ [up ramp]}}$

#5)




$m = 44\,kg$ $\quad \vec{a}_x = ?$

$\theta = 15°$

$\mu_K = 0.185$

$\vec{a}_y = 0\ m/s^2$

$\vec{g} = 9.81\ m/s^2$

$$F_{Net,x} = F_{g//} - F_F = ma_x$$

$$F_{Net,y} = F_N - F_{g\perp} = ma_y = 0N \rightarrow F_N = F_{g\perp}$$

$$ma_x = F_{g//} - F_F = F_{g//} - \mu F_N = F_{g//} - \mu F_{g\perp}$$

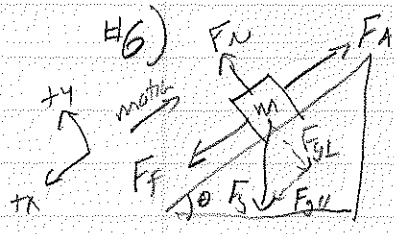
$$a_x = \frac{F_{g//} - \mu F_{g\perp}}{m} = g\sin(\theta) - \mu g\cos(\theta)$$

$$= (9.81\,m/s^2)\sin(15°) - (0.185)(9.81\,m/s^2)\cos(15°)$$

$$= 0.78600\ m/s^2$$

$$\boxed{\vec{a}_x = 0.79\ m/s^2\ [\text{down ramp}]}$$

#6)




$m = 44\,kg$ $\quad \vec{g} = 9.81\ m/s^2$ [down]

$\theta = 15°$ $\quad \vec{a}_x = 0.25\ m/s^2$

$\mu_K = 0.185$ $\quad \vec{F}_A = ?$

$\vec{a}_y = 0\ m/s^2$

$$F_{Net,y} = F_N - F_{g\perp} = 0N \rightarrow F_N = F_{g\perp} \quad (F_F = \mu F_N = \mu F_{g\perp})$$

$$F_{Net,x} = F_A - F_F - F_{g//} = ma_x \rightarrow F_A = F_F + F_{g//} + ma_x$$

$$F_A = \mu F_{g\perp} + F_{g//} + ma_x = m(\mu g\cos\theta + g\sin\theta + a_x)$$

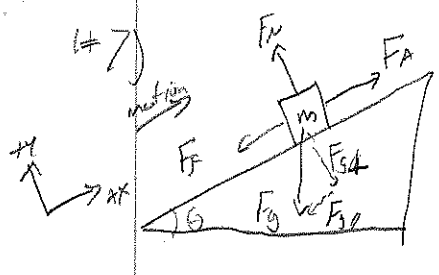
$$= (44kg)\left((0.185)(9.81\,m/s^2)\cos(15°) + (9.81\,m/s^2)\sin(15°) + 0.25\right)$$

$$= 199.849N$$

$$\boxed{F_A = 2.0\times10^2\ N\ [\text{up ramp}]}$$

# Introduction to inclined Plane

(#7)




$\vec{F}_g = 500.\,N$ [down]
$\theta = 18°$
$\vec{a}_x = 0\ m/s^2$
$\vec{a}_y = 0\ m/s^2$

$\vec{g} = 9.8\ m/s^2$ [down]
$\vec{F}_F = ?$
$\mu_k = ?$
$\vec{F}_A = 400.\,N$ [up ramp]

a) $F_{Net,x} = F_A - F_{g//} - F_F = 0\ N$

$F_F = F_A - F_{g//} = F_A - F_g \sin\theta$

$F_F = 400.\,N - (500.\,N)\sin(18°) = 245.49\ N$

$\boxed{\vec{F}_F = 245\,N \text{ [down ramp]}}$

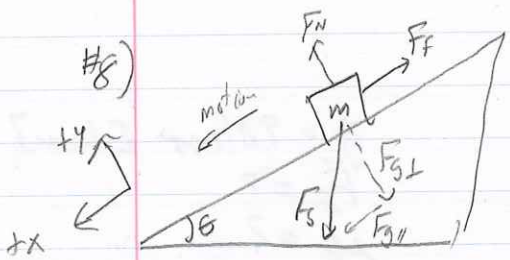
b) $F_{Net,y} = F_N - F_{g\perp} = 0\ N \rightarrow F_N = F_{g\perp}$

$F_F = \mu_k F_N \rightarrow \mu_k = \frac{F_F}{F_N} = \frac{F_F}{F_{g\perp}} = \frac{F_F}{F_g \cos\theta}$

$\mu_k = \frac{(245.49\,N)}{(500.\,N)\cos(18°)} = 0.51625$

$\boxed{\mu_k = 0.516}$

#8)




$\theta = 20°$

$\mu_k = 0.215$

$a_y = 0 \text{ m/s}^2$

$\vec{g} = 9.81 \text{ m/s}^2$ [down]

$\vec{a}_x = ?$

$$F_{Net,y} = F_N - F_{g\perp} = 0N \rightarrow F_N = F_{g\perp}$$

$$F_{Net,x} = F_{g\parallel} - F_f = ma_x$$

$$F_{g\parallel} - \mu_k F_N = ma_x$$

$$a_x = \frac{F_{g\parallel} - \mu_k F_{g\perp}}{m} = \frac{mg\sin\theta - \mu_k mg\cos\theta}{m}$$

$$a_x = g(\sin(\theta) - \mu\cos(\theta))$$

$$= (9.81 \text{ m/s}^2)(\sin(20°) - (0.215)\cos(20°))$$

$$= 1.37326 \text{ m/s}^2$$

$$\boxed{\vec{a}_x = 1.37 \text{ m/s}^2 \text{ [down ramp]}}$$