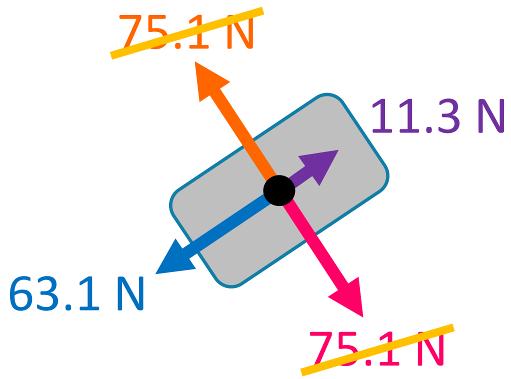
# Forces on a Ramp

IB PHYSICS | FORCES

# Warm up

What is the acceleration of this 10 kg block?




$F_{\text{net}} = 51.8\text{ N}$

$$a = \frac{F_{net}}{m} = \frac{51.8\text{ N}}{10\text{ kg}}$$

$$F_{net} = ma$$

$$\boxed{a = \mathbf{5.18\ m\ s^{-2}}}$$

# Big Ideas so Far….

Acceleration is zero when net force is zero

This doesn’t mean just mean “stopped” (constant velocity)

If you have acceleration of an object, you can find the net force causing that acceleration

(Think $F = ma$)

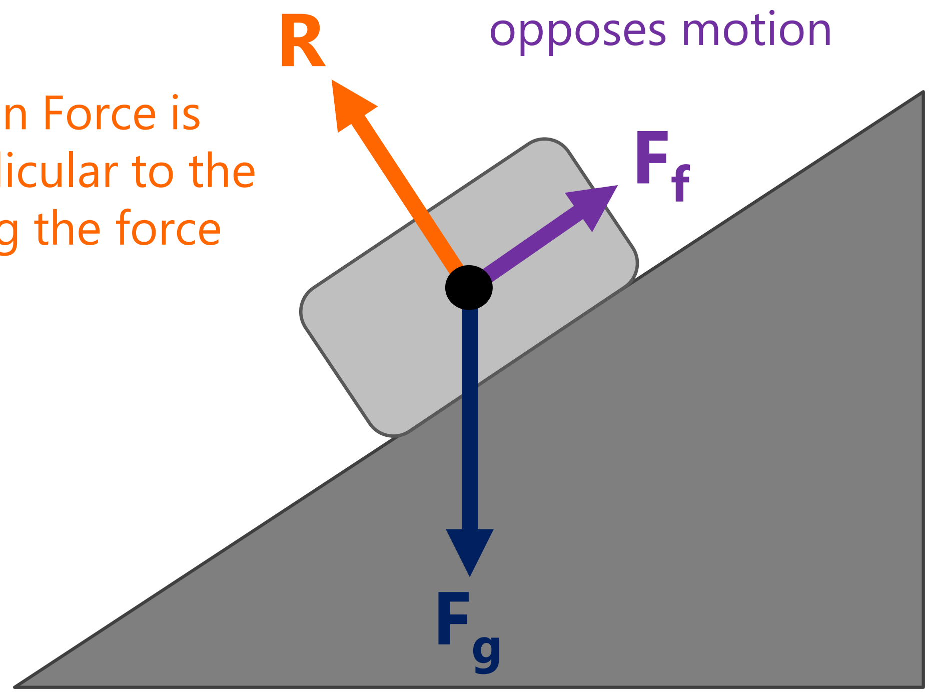
Force of friction is related to the normal force by the coefficient of friction ($\mu$)

$$F_f = \mu R$$

# What Forces are acting?

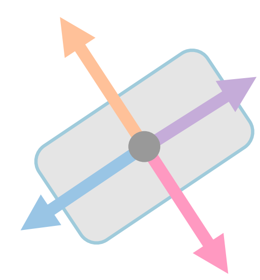
Force of Friction always opposes motion

Normal Reaction Force is always perpendicular to the surface applying the force




Force of Gravity is always straight down

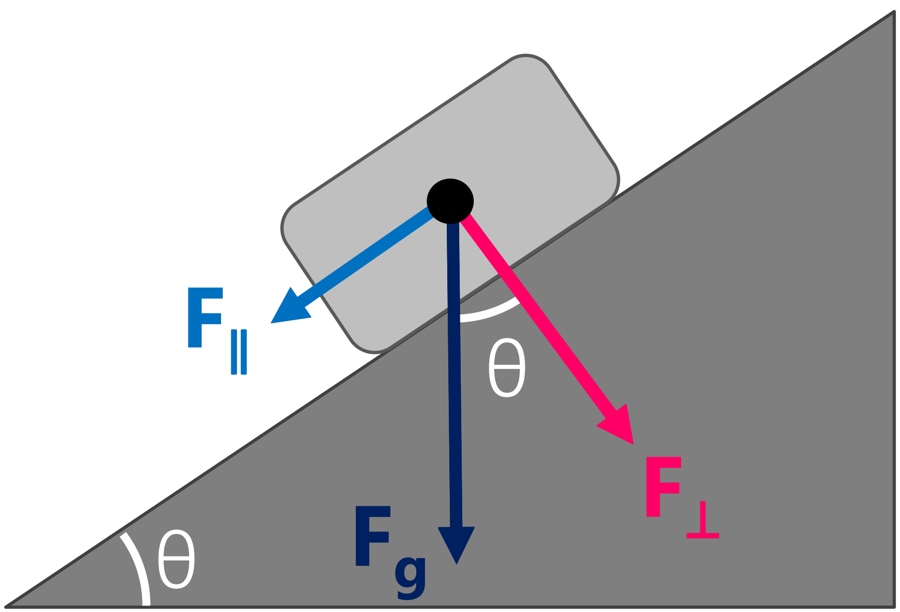
What we need to calculate $F_{net}$



# Components of $F_g$

We try to choose our axes so that we are only looking at forces that are parallel and perpendicular to the motion.

This means that we need to break $F_g$ down into components! ☺

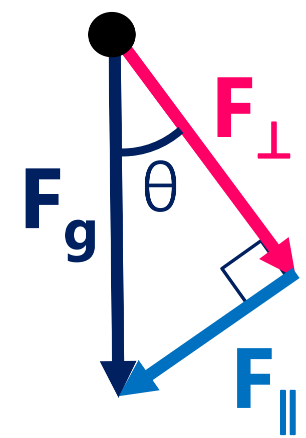



$\sin\theta = F_\parallel / F_g$

$F_\parallel = F_g \sin\theta$

$\cos\theta = F_\perp / F_g$

$F_\perp = F_g \cos\theta$



# Normal and Friction Forces on Ramp

## Normal Reaction Force (R)

Force perpendicular to the surface

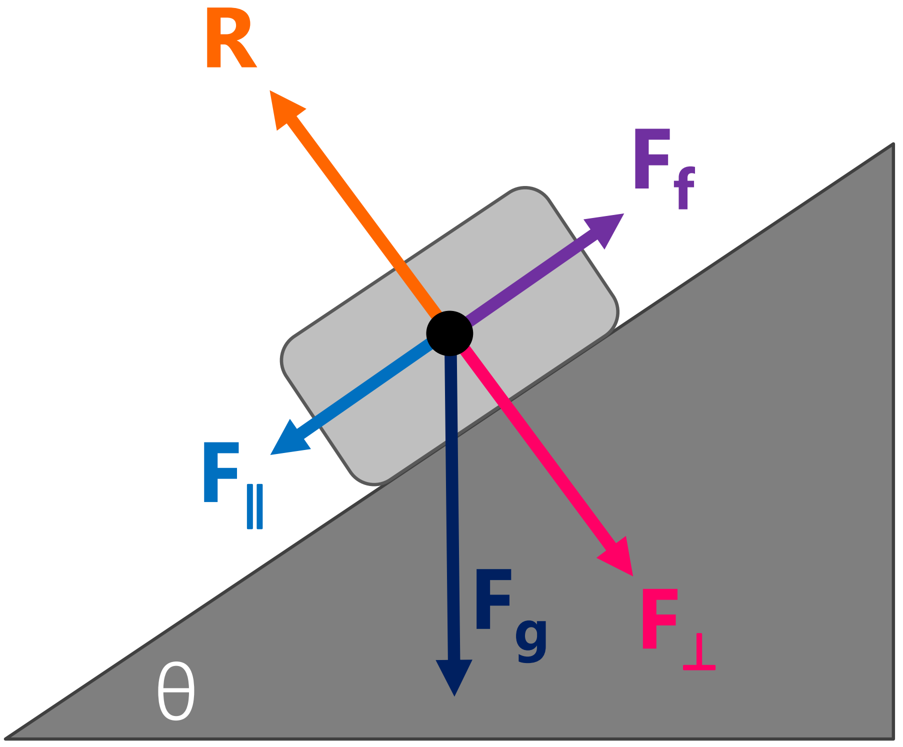
$$R = F_{\perp}$$

## Friction Force ($F_f$)

$$F_f = \mu R$$

*For Equilibrium

$$F_f = F_{\parallel}$$



# Example IB Question

A wooden block is sliding down an inclined plane at constant speed. The magnitude of the frictional force between the block and the plane is equal to

A. zero.

B. the magnitude of the weight of the block.

C. the magnitude of the component of weight of the block parallel to the plane.

D. the magnitude of the component of the normal reaction parallel to the plane.

# Ramp Example

$F_g = mg = (10)(9.81) = \mathbf{98.1\ N}$

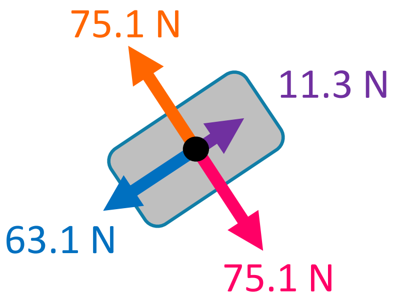
$F_\perp = F_g\cos\theta = 98.1 \times \cos(40) = \mathbf{75.1\ N}$

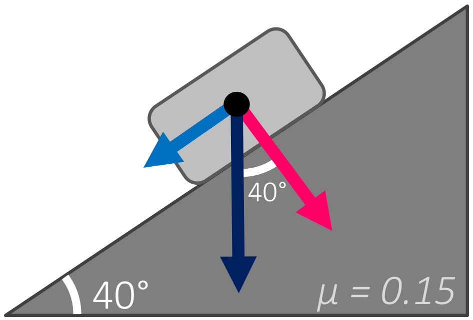
$F_\parallel = F_g\sin\theta = 98.1 \times \sin(40) = \mathbf{63.1\ N}$

$R = F_\perp = \mathbf{75.1\ N}$

$F_f = \mu R = (0.15)(75.1) = \mathbf{11.3\ N}$

| | |
|---|---|
| $m$ | 10 kg |
| $F_g$ | 98.1 N |
| $F_\perp$ | 75.1 N |
| $F_\parallel$ | 63.1 N |
| $R$ | 75.1 N |
| $F_f$ | 11.3 N |
| $F_{net}$ | |
| $a$ | |



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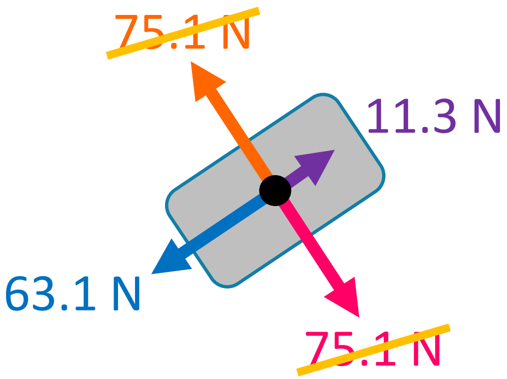


$$F_{net} = 51.8 \text{ N}$$

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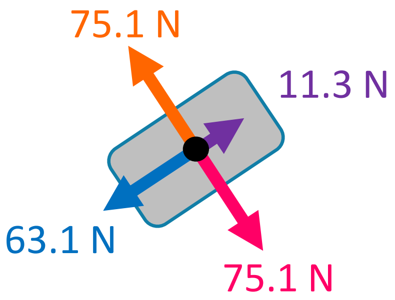
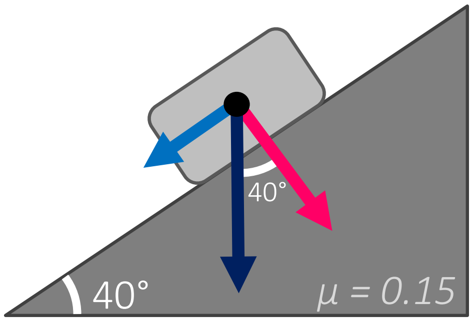
$R = F_\perp = \mathbf{75.1\ N}$

$F_f = \mu R = (0.15)(75.1) = \mathbf{11.3\ N}$

$F_{net} = 63.1 - 11.3 = \mathbf{51.8\ N}$

$a = F/m = 51.8/10 = \mathbf{5.18\ m\ s^{-2}}$

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| $R$ | 75.1 N |
| $F_f$ | 11.3 N |
| $F_{net}$ | 51.8 N |
| $a$ | 5.18 m $s^{-2}$ |

# What if we didn't know mass?

$F_g = mg$

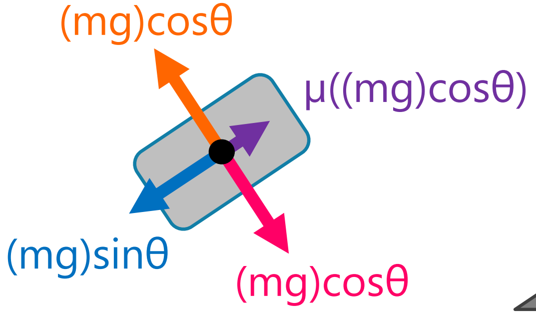
$F_{\perp} = F_g\cos\theta = (mg)\cos\theta$

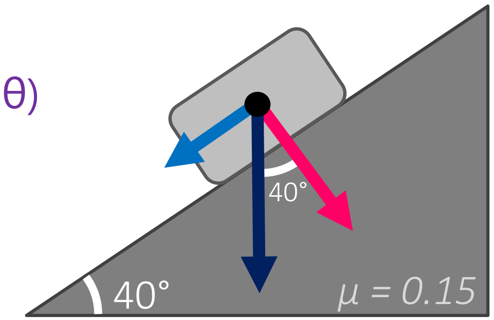
$F_{\parallel} = F_g\sin\theta = (mg)\sin\theta$

$R = F_{\perp} = (mg)\cos\theta$

$F_f = \mu R = \mu((mg)\cos\theta)$

$$F_{net} = ma = (mg)\sin\theta - \mu((mg)\cos\theta)$$
$$a = (g)\sin\theta - \mu((g)\cos\theta)$$




**For this Example…**

$a = (9.81)\sin 40 - 0.15((9.81)\cos 40)$

$a = 6.31 - 1.13$

$a = \mathbf{5.18\ m\ s^{-2}}$

# Lesson Takeaways

- ❑ I can calculate parallel and perpendicular components of the force due to gravity on a ramp
- ❑ I can calculate the force of friction required to keep an object in equilibrium
- ❑ I can calculate the acceleration of an object with known mass on a ramp of known angle and friction
- ❑ I can symbolically simplify a mathematical model to cancel out unnecessary information