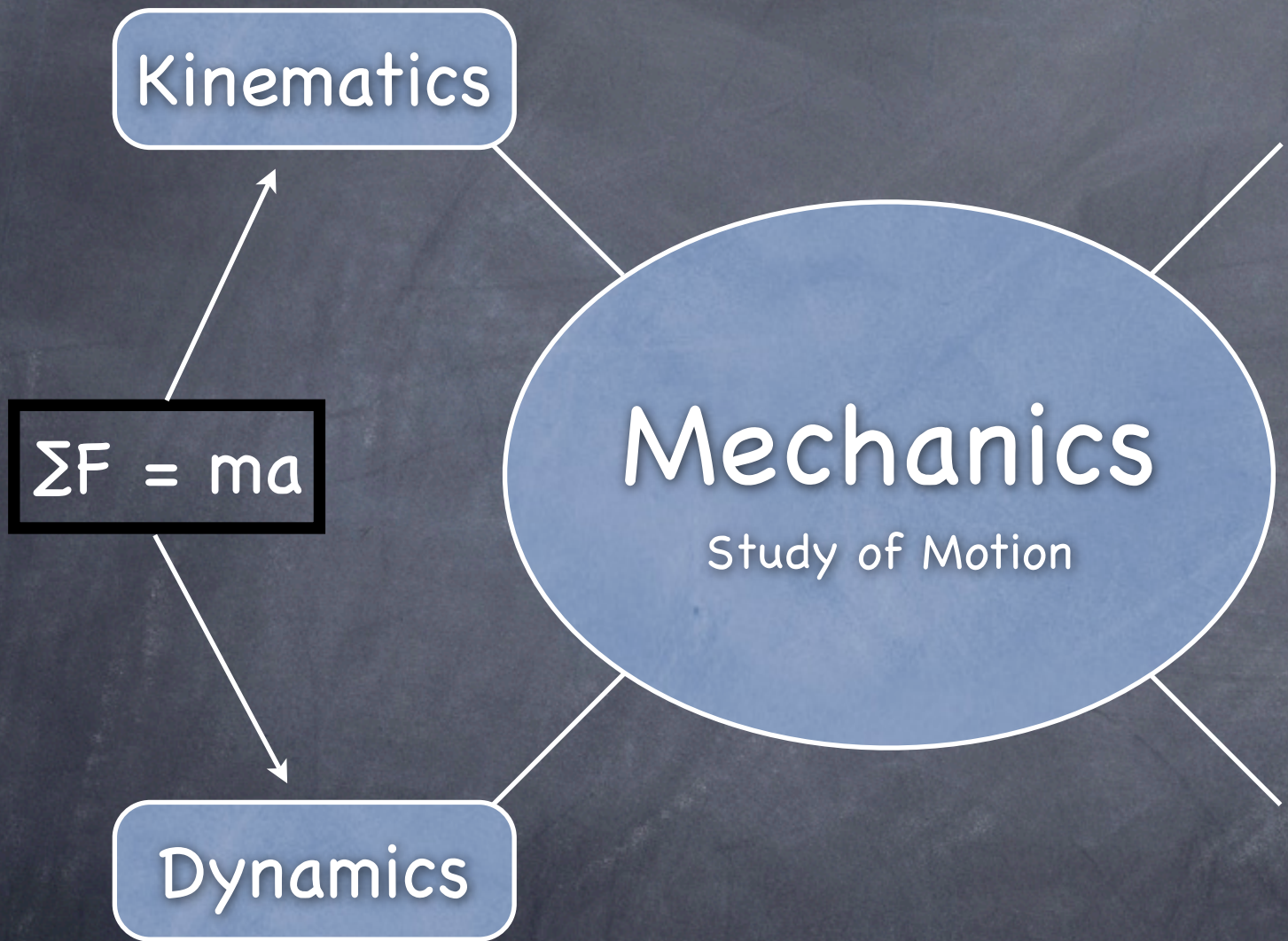
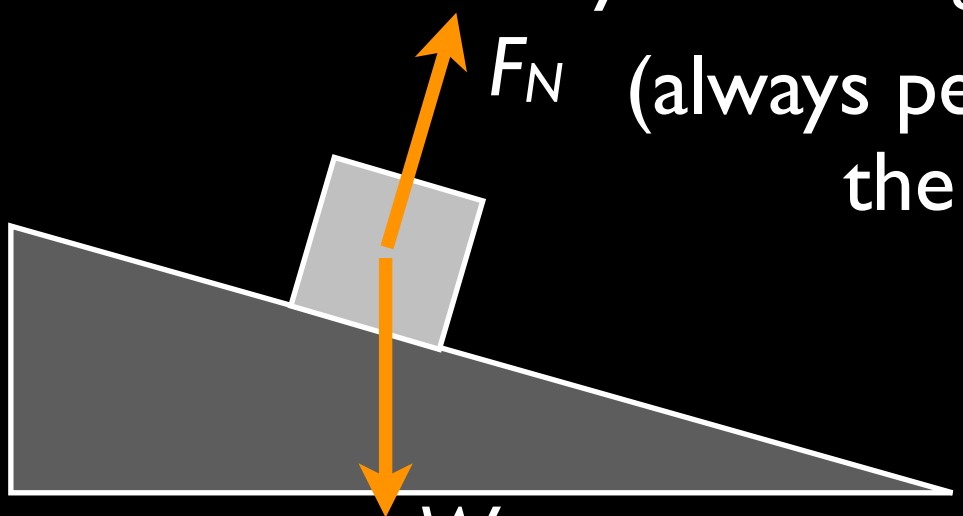

Kinematics
ΣF = ma
Mechanics
Study of Motion
Dynamics

Unit 3b:
2-D Dynamics

How do Newton's Laws apply to motion in two dimensions?

The Inclined Plane

- An object is placed on a frictionless incline plane. Draw a free-body force diagram.

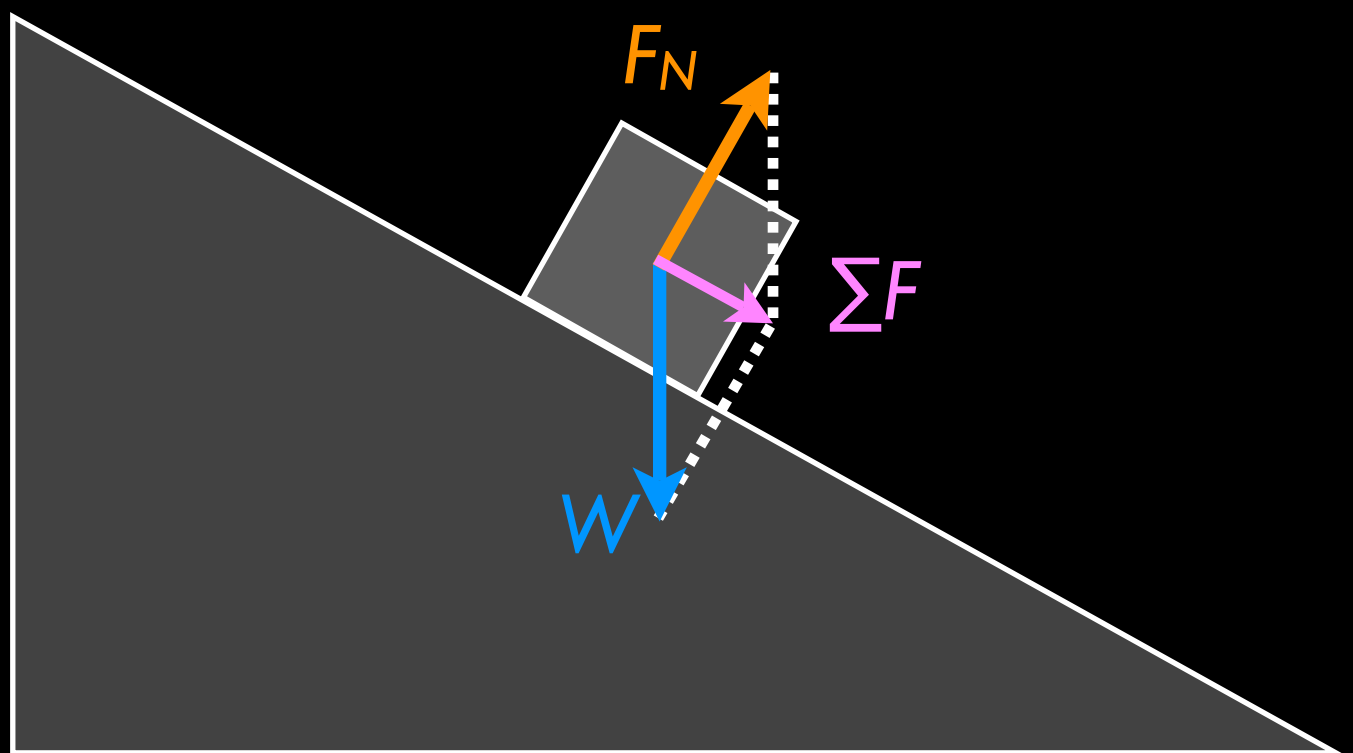


(always perpendicular to the surface)

(always points toward center of Earth)

The Inclined Plane

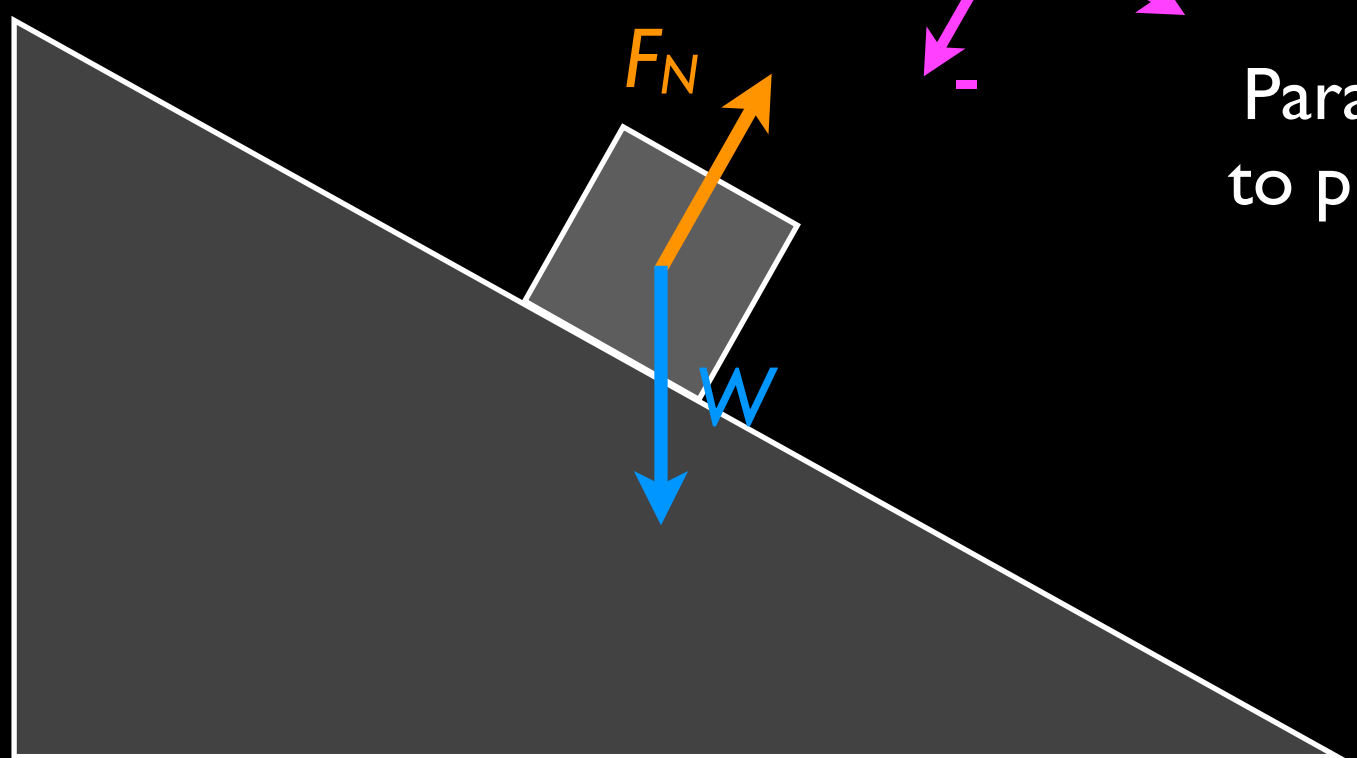
- Why do objects slide down ramps?



The net force points down the ramp, so the object accelerates down the ramp.

The Inclined Plane

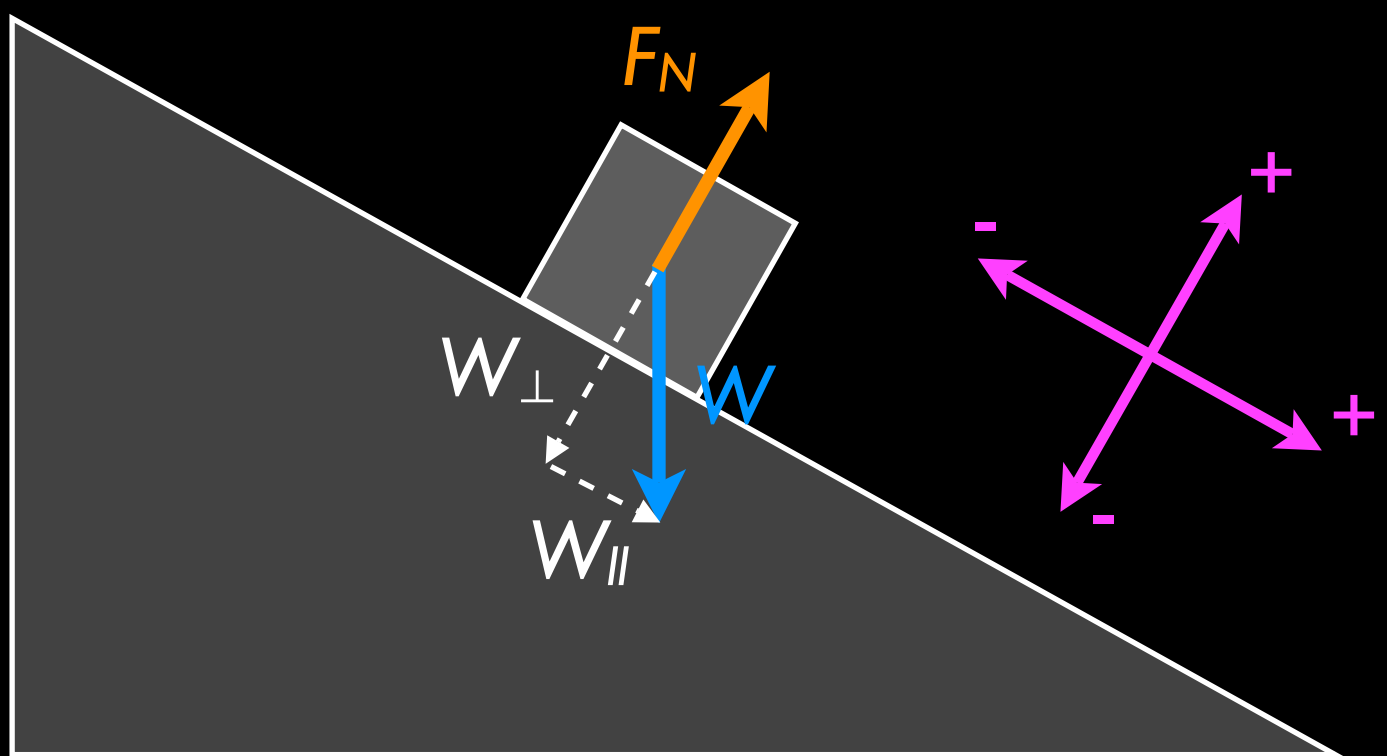
- How are we going to deal with incline planes mathematically?
  - Coordinate system:



The Inclined Plane

- How are we going to deal with incline planes mathematically?
  - Break *W* into its parallel and perpendicular components ($W_{//}$ and $W_{\perp}$)

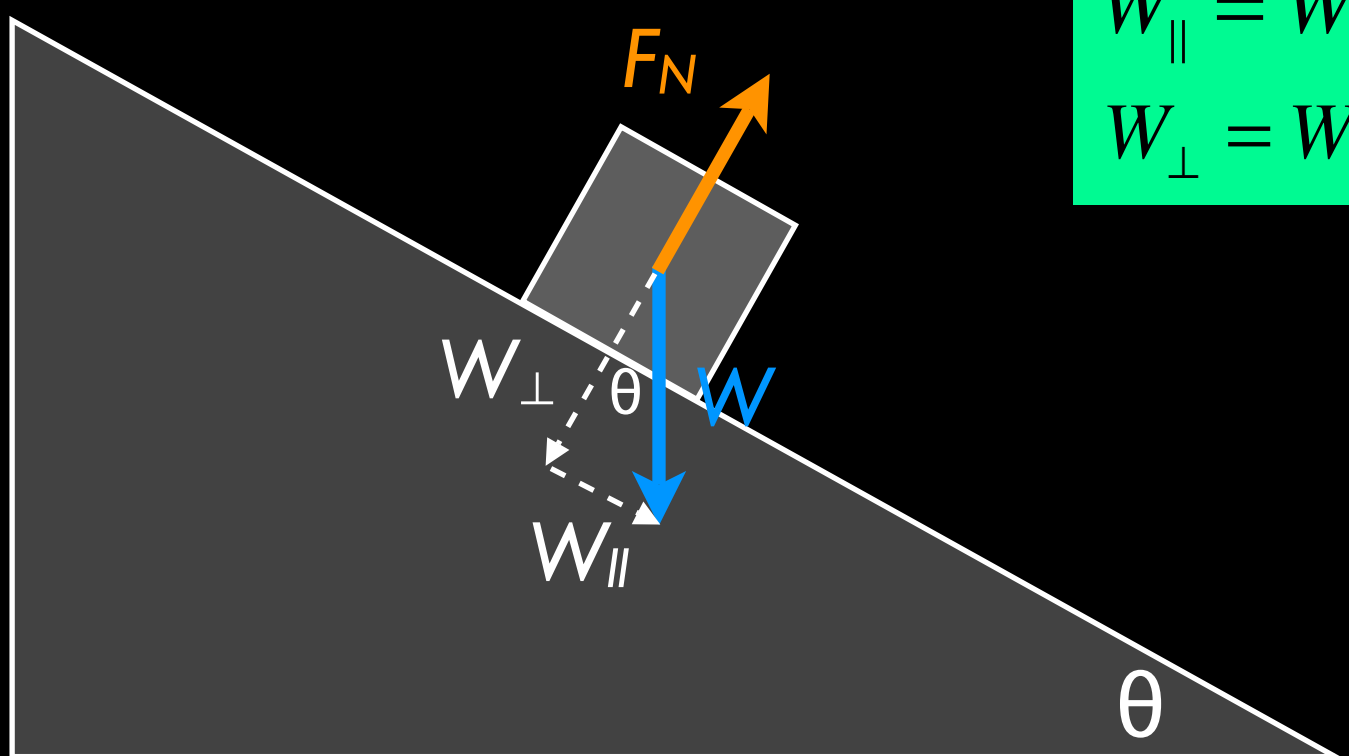
$F_N = W_{\perp}$



The Inclined Plane

- How can we determine the magnitude of $W_{\parallel}$ and $W_{\perp}$?
  - Angle of ramp = angle between W and $W_{\perp}$

$$W_{\parallel} = W \sin\theta$$
$$W_{\perp} = W \cos\theta$$



The Inclined Plane

- A 20-kg block sits on an inclined plane. Determine the parallel and perpendicular components of the gravitational force if the angle is:
  - 20 degrees.
  - 40 degrees.
  - 60 degrees.

$W_{\parallel} = (20\ kg)(9.8\ N/kg)(\sin 20^{o}) = 67\ N$
$W_{\perp} = (20\ kg)(9.8\ N/kg)(\cos 20^{o}) = 184\ N$

$W_{\parallel} = (20\ kg)(9.8\ N/kg)(\sin 40^{o}) = 126\ N$
$W_{\perp} = (20\ kg)(9.8\ N/kg)(\cos 40^{o}) = 150\ N$

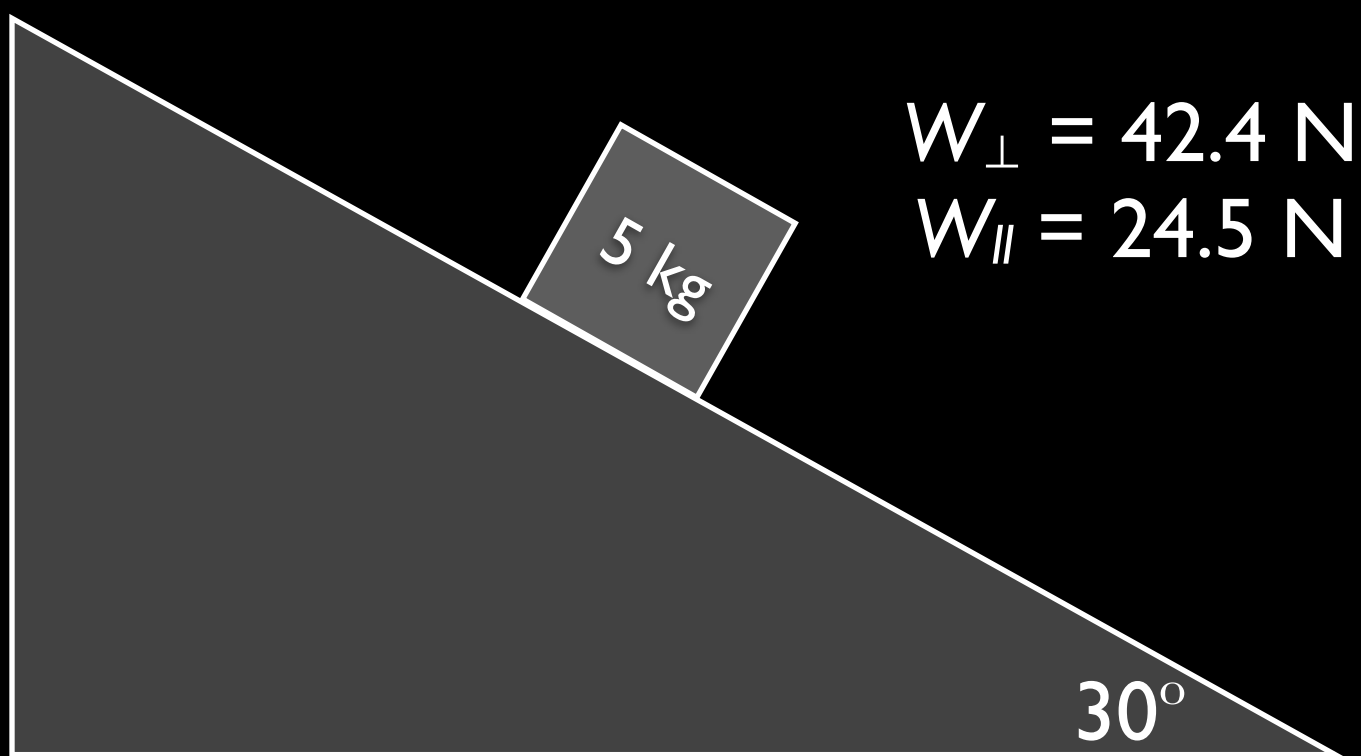
$W_{\parallel} = (20\ kg)(9.8\ N/kg)(\sin 60^{o}) = 170\ N$
$W_{\perp} = (20\ kg)(9.8\ N/kg)(\cos 60^{o}) = 98\ N$

Homework: Prove that the angle of the ramp = angle of gravity triangle

Inclined Plane Problems

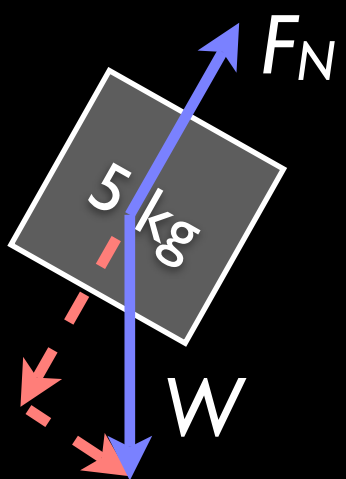
- Determine the acceleration of the object as it goes down the frictionless plane:

• Step 1: FBFD & components of W



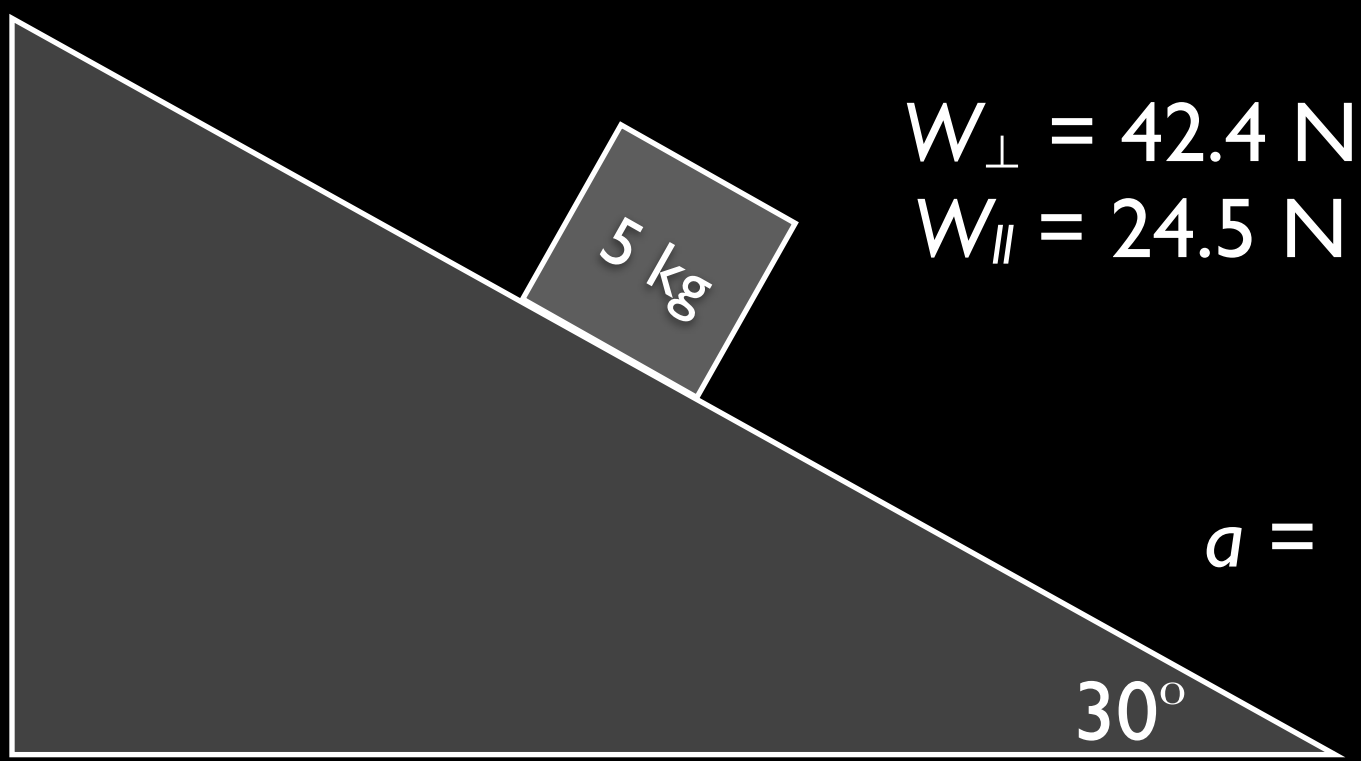
$W_{\perp} = 42.4$ N

$W_{//} = 24.5$ N



Inclined Plane Problems

- Determine the acceleration of the object as it goes down the frictionless plane:



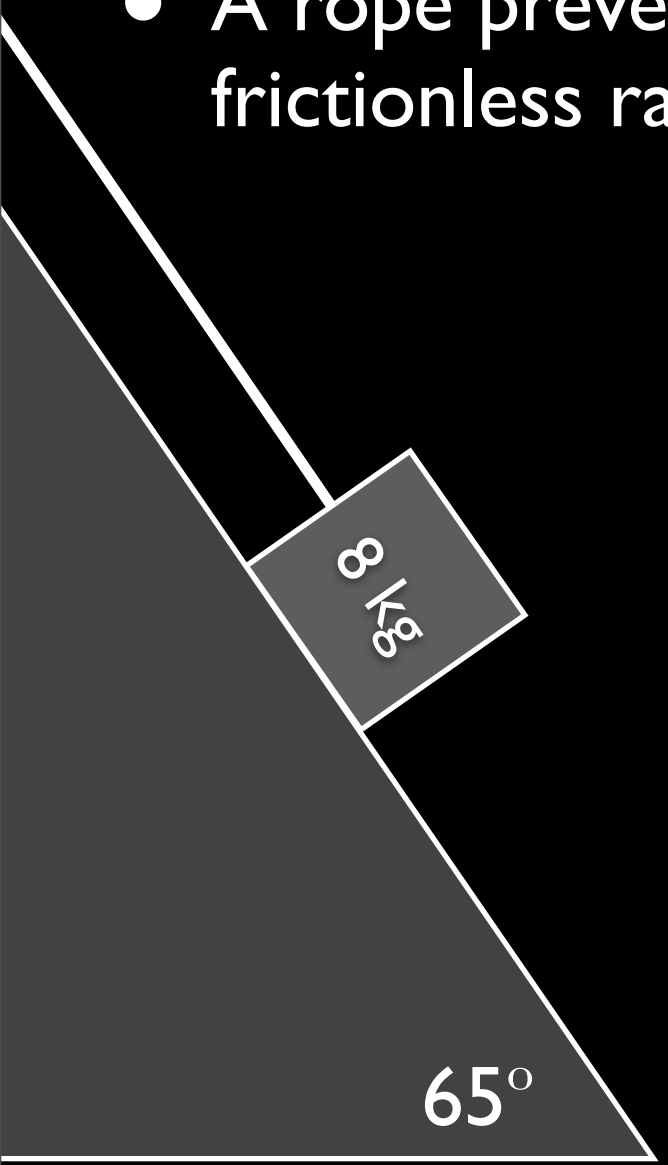
$W_{\perp} = 42.4\ \text{N} = F_N$

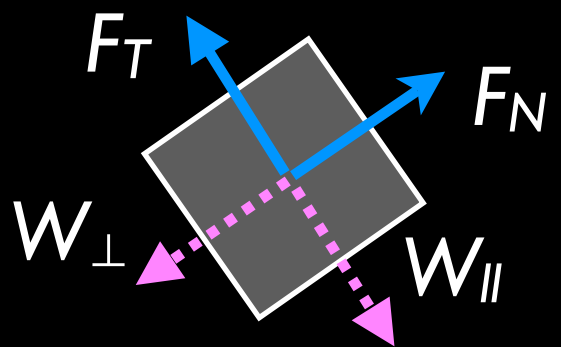
$W_{//} = 24.5\ \text{N} = \sum F$

$$a = \frac{\sum F}{m} = 4.9\ \text{m/s}^2$$

Inclined Plane Problems

- A rope prevents the block from sliding down the frictionless ramp. Determine the tension in the rope.





$\sum F = 0$, so:

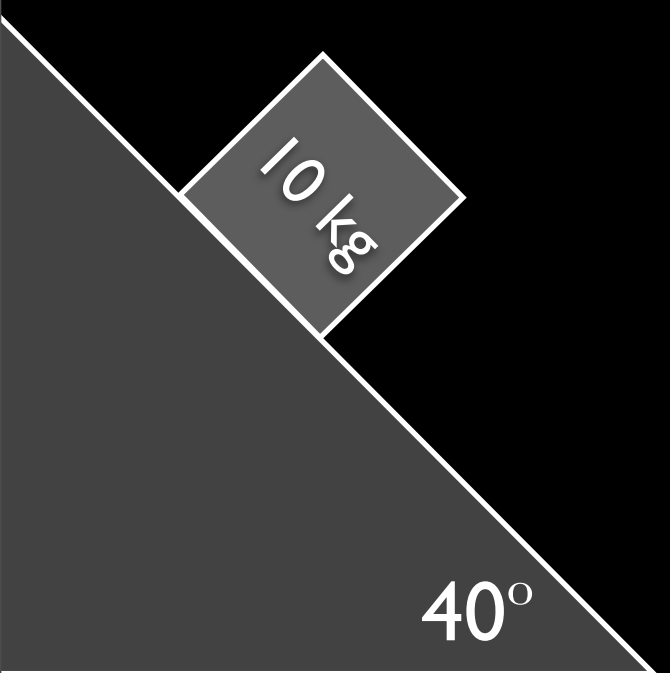
$F_N = W_\perp$

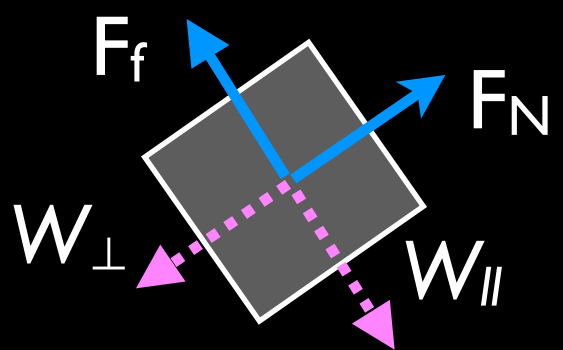
$F_T = W_{||}$ $= (8\text{ kg})(9.8\text{ N/kg})(\sin 65^\circ)$

$= 71.1\text{ N}$

Inclined Plane Problems

- Friction prevents the block from sliding down the ramp. Determine the minimum value μ_s could be.





$\sum F = 0$, so:

$F_N = W_\perp = 75.1$ N

$F_f = W_{//} = 63.0$ N

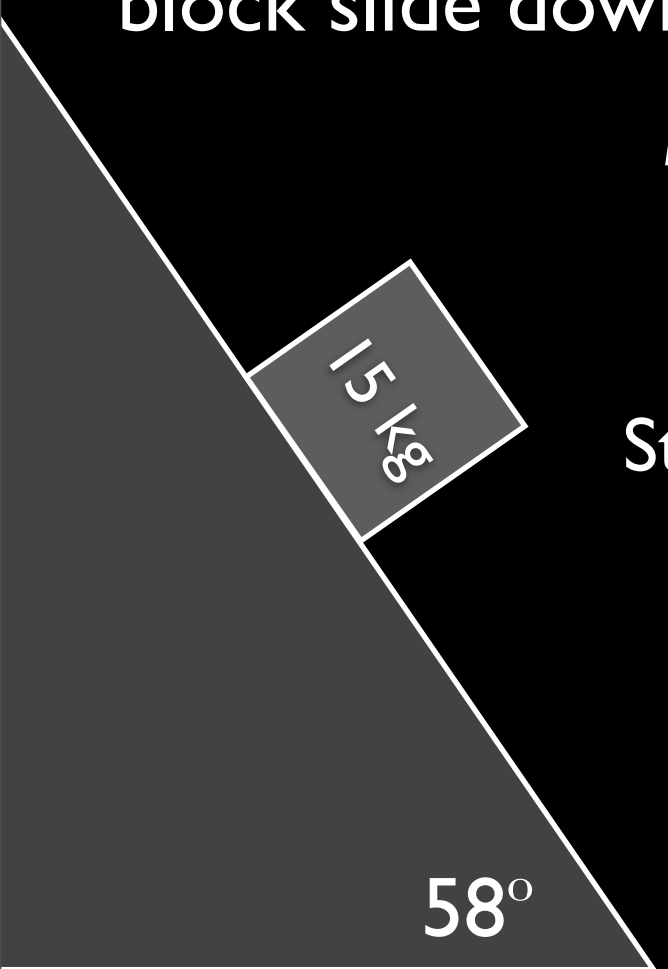
$F_f \leq \mu_s F_N$

$F_f / F_N \leq \mu_s$

$\mu_s \geq 0.839$

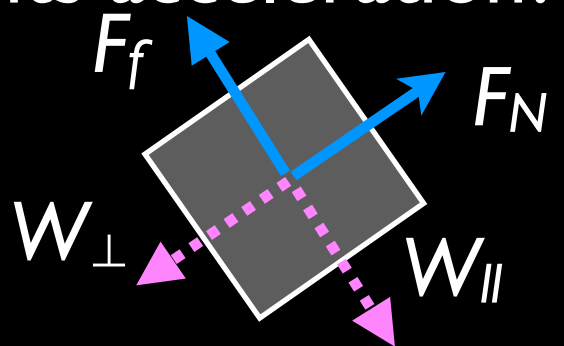
Inclined Plane Problems

- The coefficient of static and kinetic friction between the block and ramp are 0.62 and 0.38, respectively. Will the block slide down the ramp? If so, what is its acceleration?



$F_N = W_\perp = 77.9$ N

$W_{//} = 125$ N



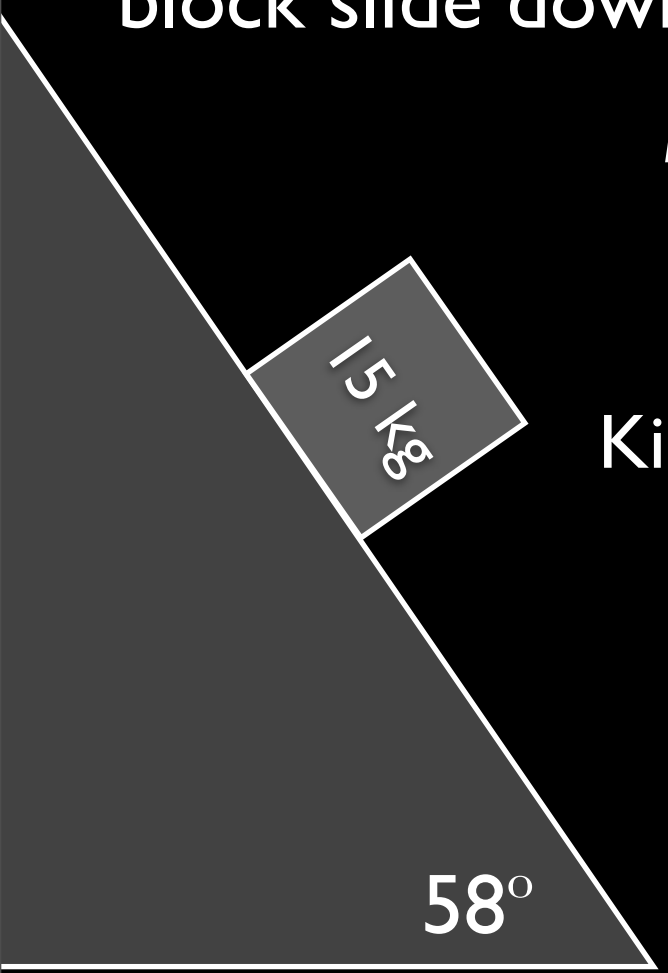
Static Friction: $F_f \leq \mu_s F_N$

$F_f \leq 48.3$ N

Max. static friction force (48.3 N) is less than $W_{//}$, so the block will slide down the ramp!

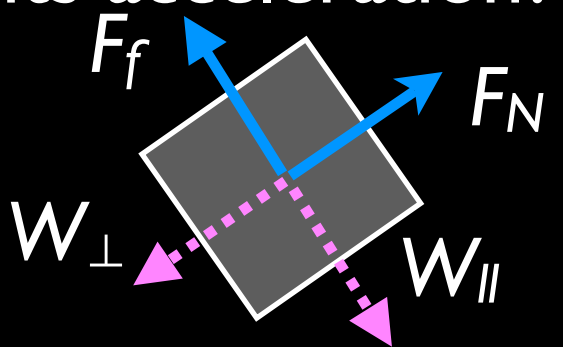
Inclined Plane Problems

- The coefficient of static and kinetic friction between the block and ramp are 0.62 and 0.38, respectively. Will the block slide down the ramp? If so, what is its acceleration?



$F_N = W_\perp = 77.9$ N

$W_{||} = 125$ N



Kinetic Friction: $F_f = \mu_k F_N$

$F_f = 29.6$ N

$\sum F = 125$ N - 29.6 N = 95.4 N (down the ramp)

$$a = \frac{95.4 \text{ N}}{15 \text{ kg}} = 6.36 \text{ m/s}^2$$