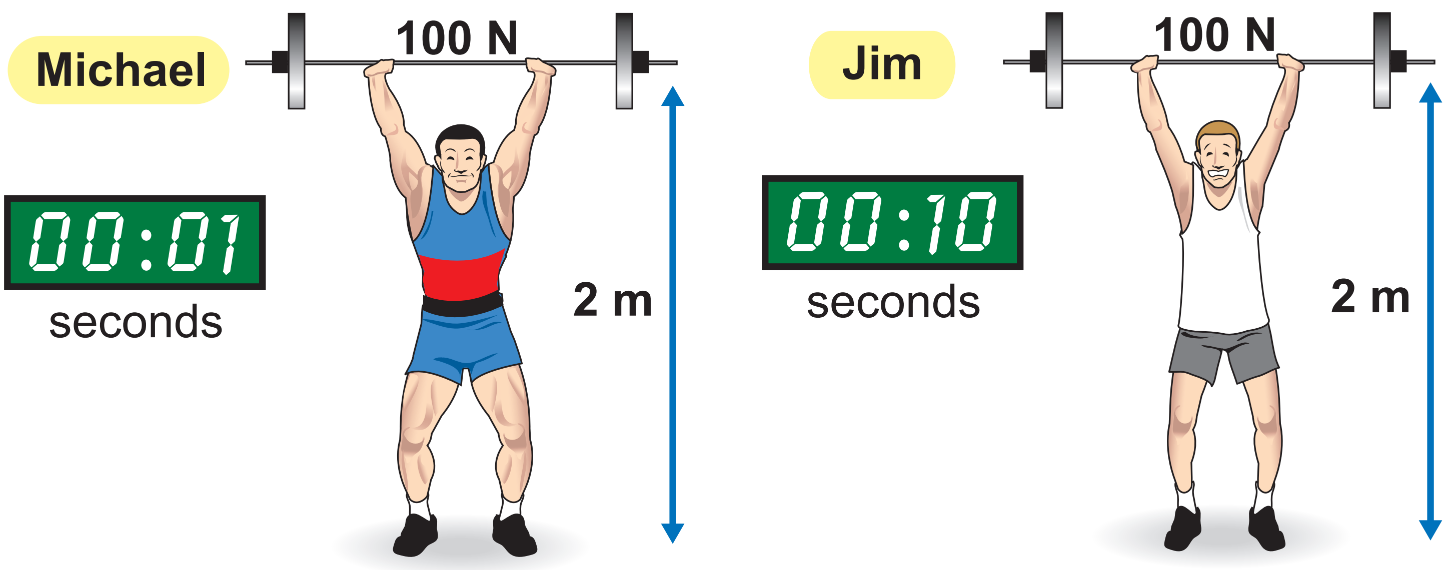
Power

Power (watts) → $P = \frac{W}{t}$ ← *Work* (joules), *Time* (seconds)



Michael and Jim do the same amount of work
but do not have the same power.

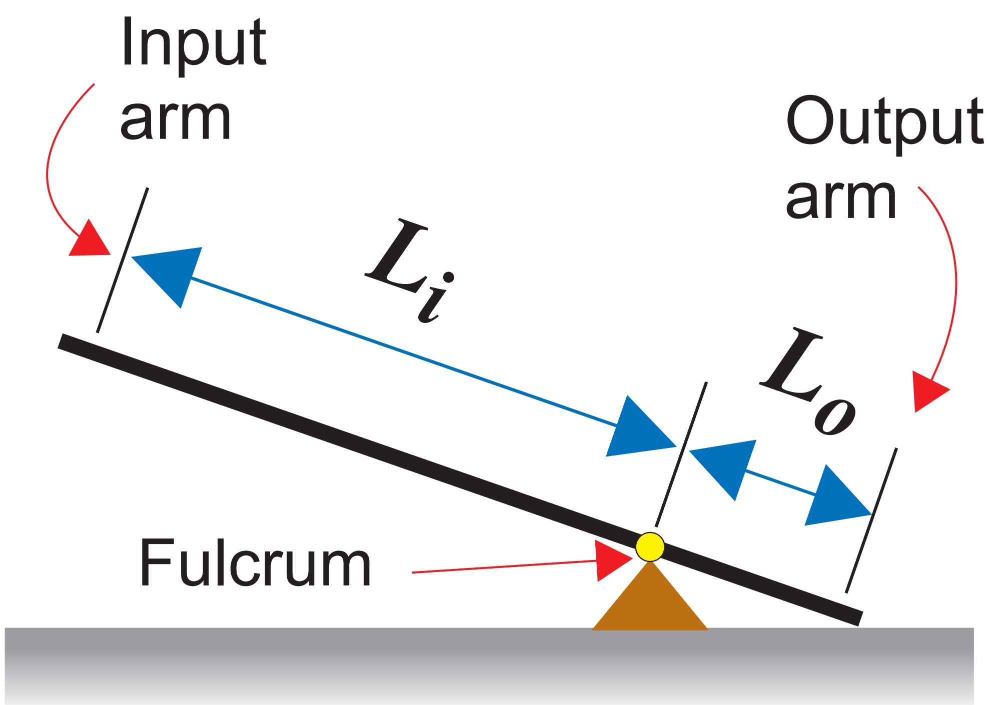
Mechanical Advantage of a Lever

$$MA_{lever} = \frac{L_i}{L_o}$$

Mechanical advantage → MA_{lever}

L_i: *Length of input arm* (m)

L_o: *Length of output arm* (m)



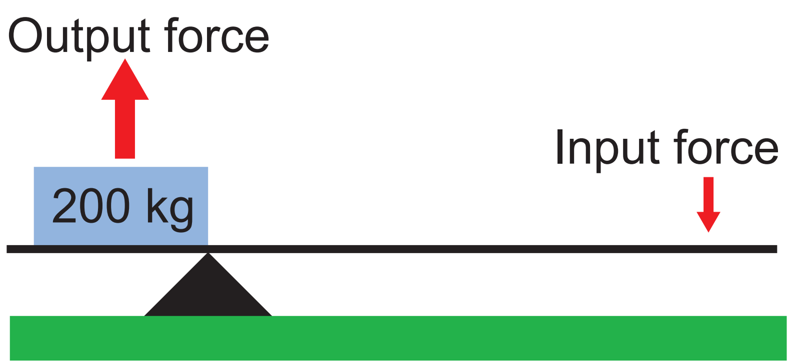
Mechanical Advantage

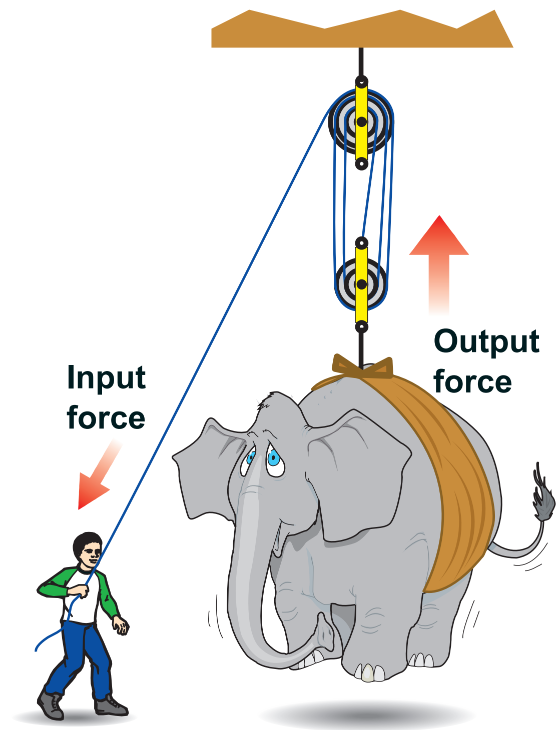
$$MA = \frac{F_o}{F_i}$$

Mechanical advantage → MA

F_o ← *Output force* (N)

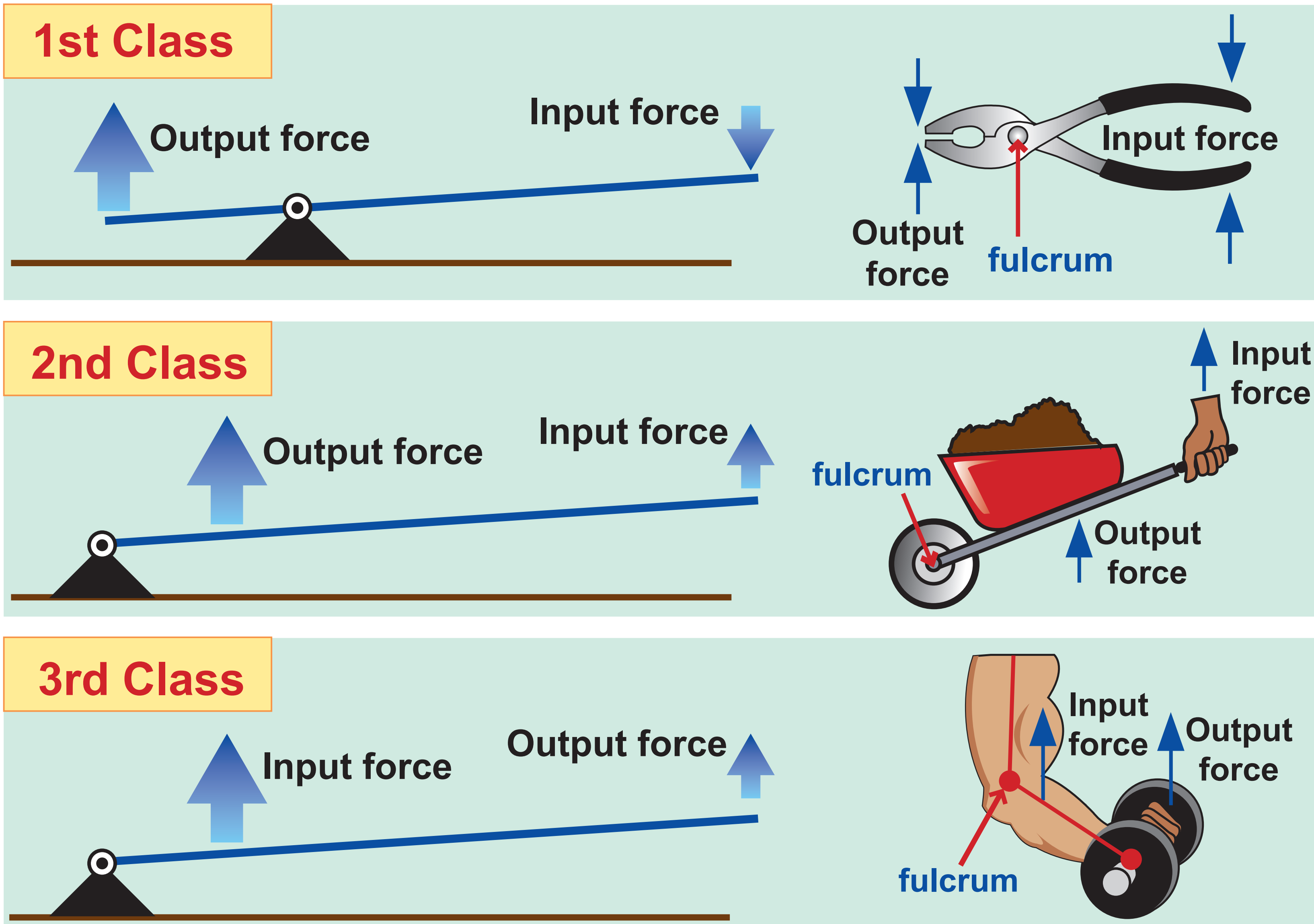
F_i ← *Input force* (N)



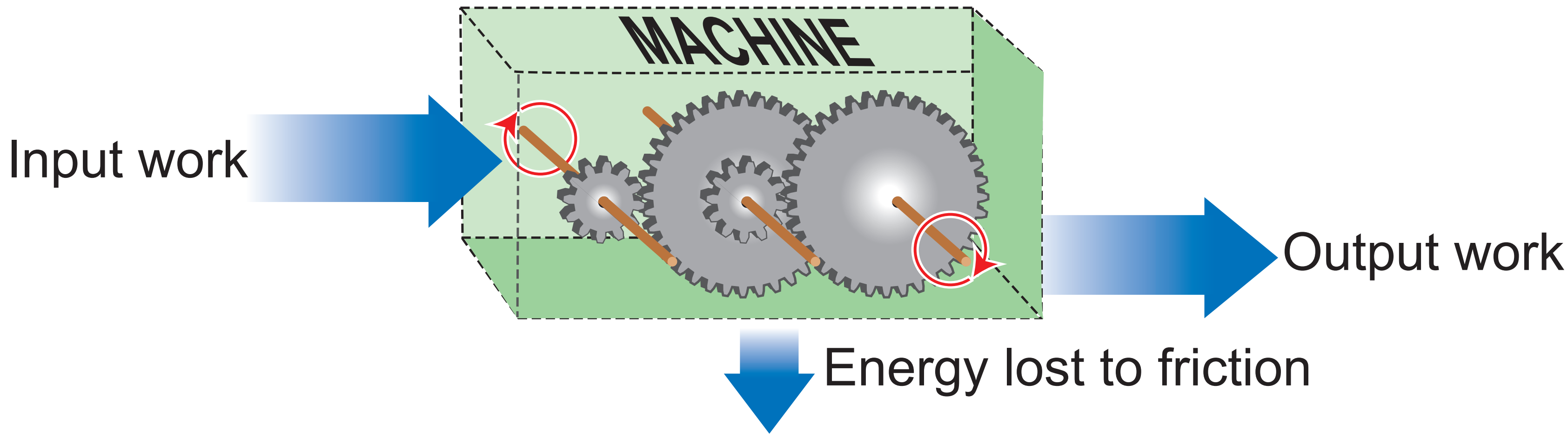


A small input force can create a large output force
for simple machines with a mechanical advantage greater than one.

The Three Classes of Levers

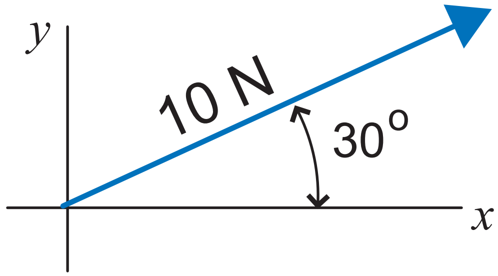


Efficiency



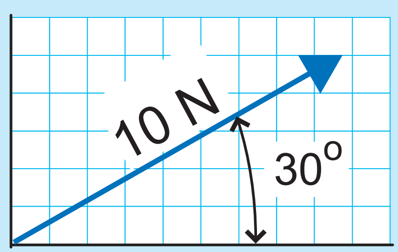
$$\text{Efficiency} = \frac{\text{Output work}}{\text{Input work}}$$

Three Ways to Describe the Same Force

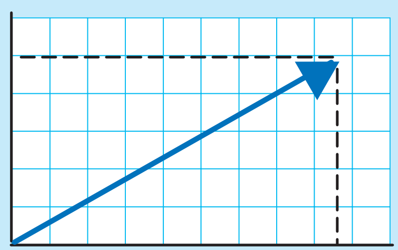
Graph	Magnitude, angle	*x-y* pair
	(10 N, 30°)	(8.6, 5.0) N

Finding the components

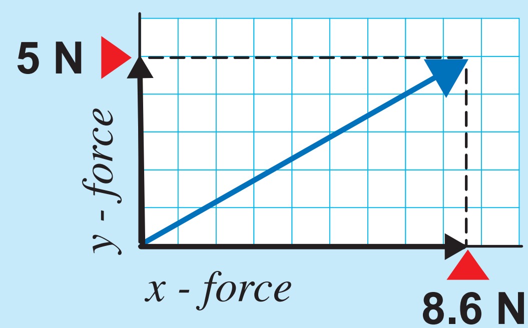
1. Draw the force to scale



2. Extend lines to the *x* and *y* axes

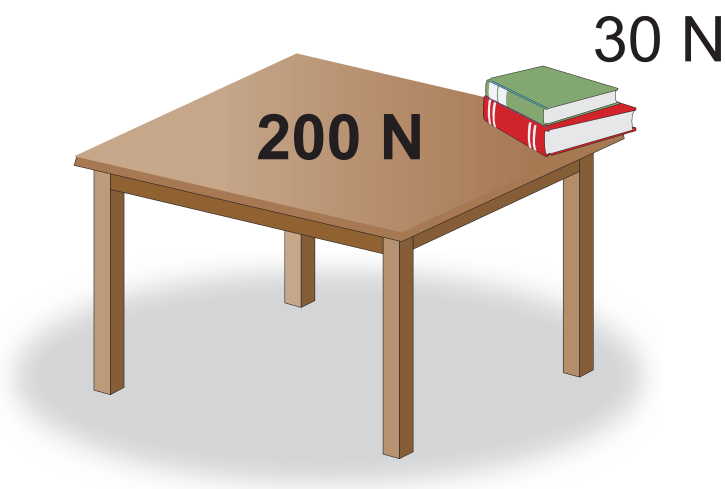


3. Read off the *x* and *y* components

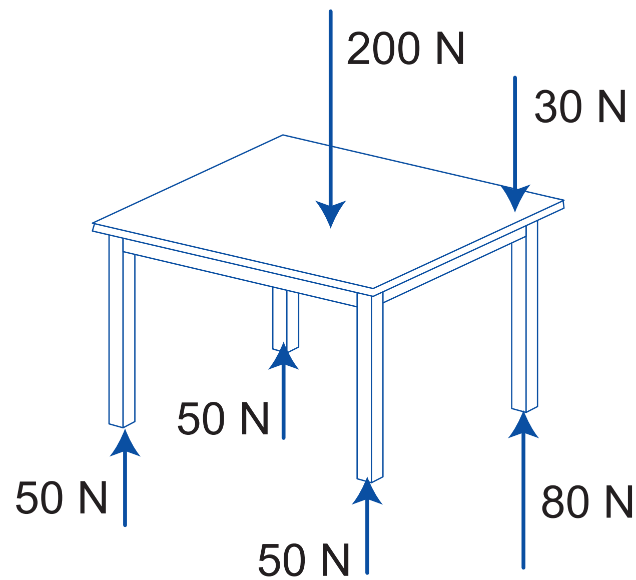


Free-body Diagram

Real-life situation



Free-body diagram



Downward forces	Upward forces	Equilibrium condition
Table top -200 N	+ 50 N (**Table legs**)	+ 50 N
Books -30 N	+ 50 N (**Table legs**)	+ 50 N
-230 N	+ 50 N (**Table legs**)	-200 N / + 50 N
	+ 80 N — **Supporting table leg**	-30 N / + 80 N
	+ 230 N	-230 N / + 230 N

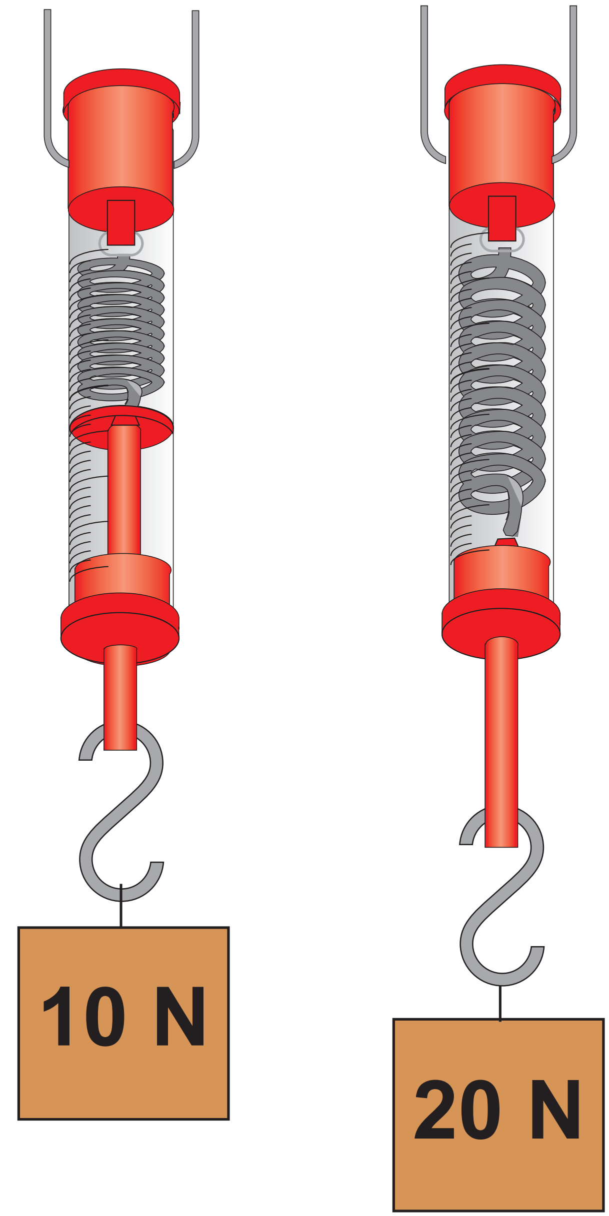
Hooke's Law

Force (newtons)

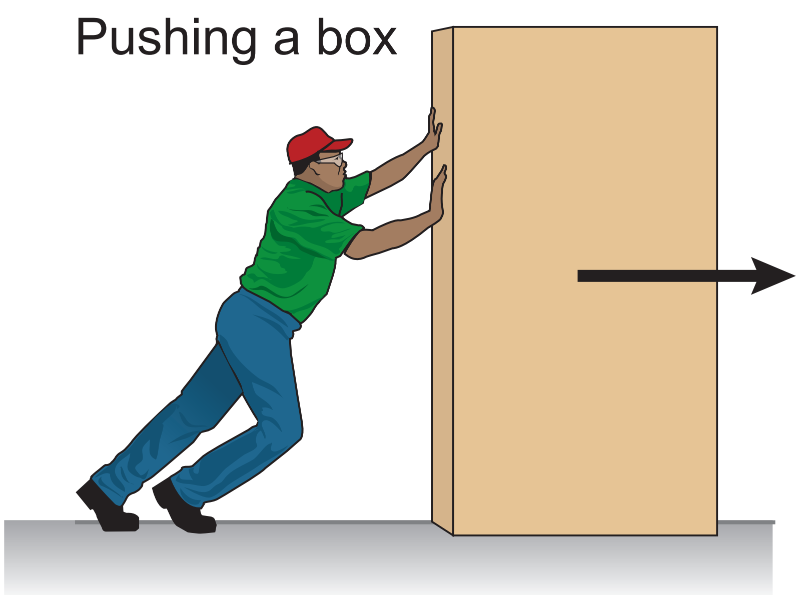
Extension or compression (meters)

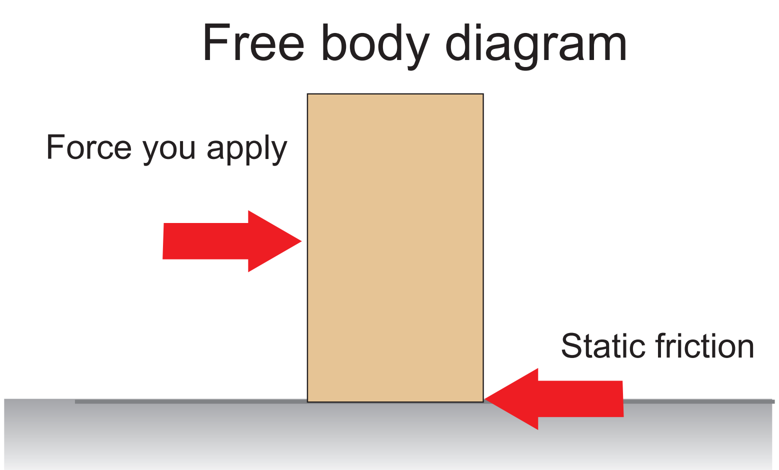
$$F = -kx$$

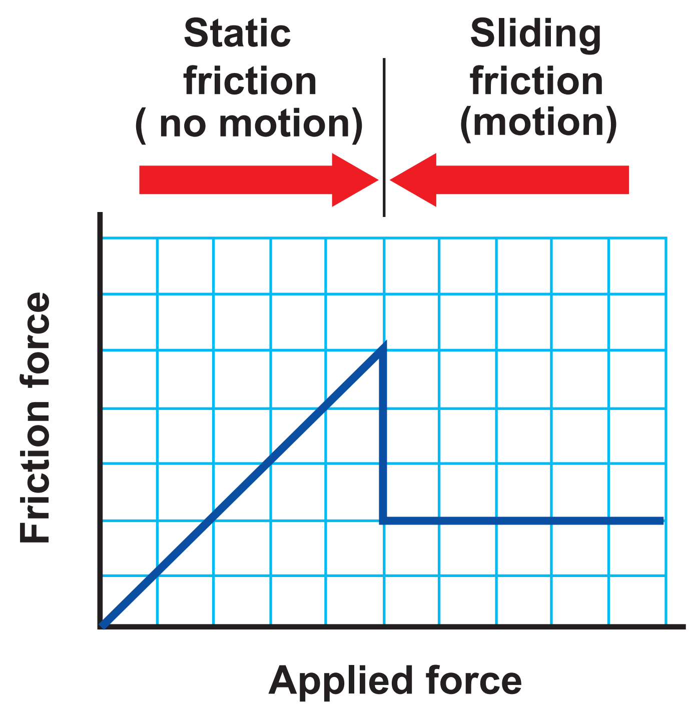
Spring constant (newtons/meters)



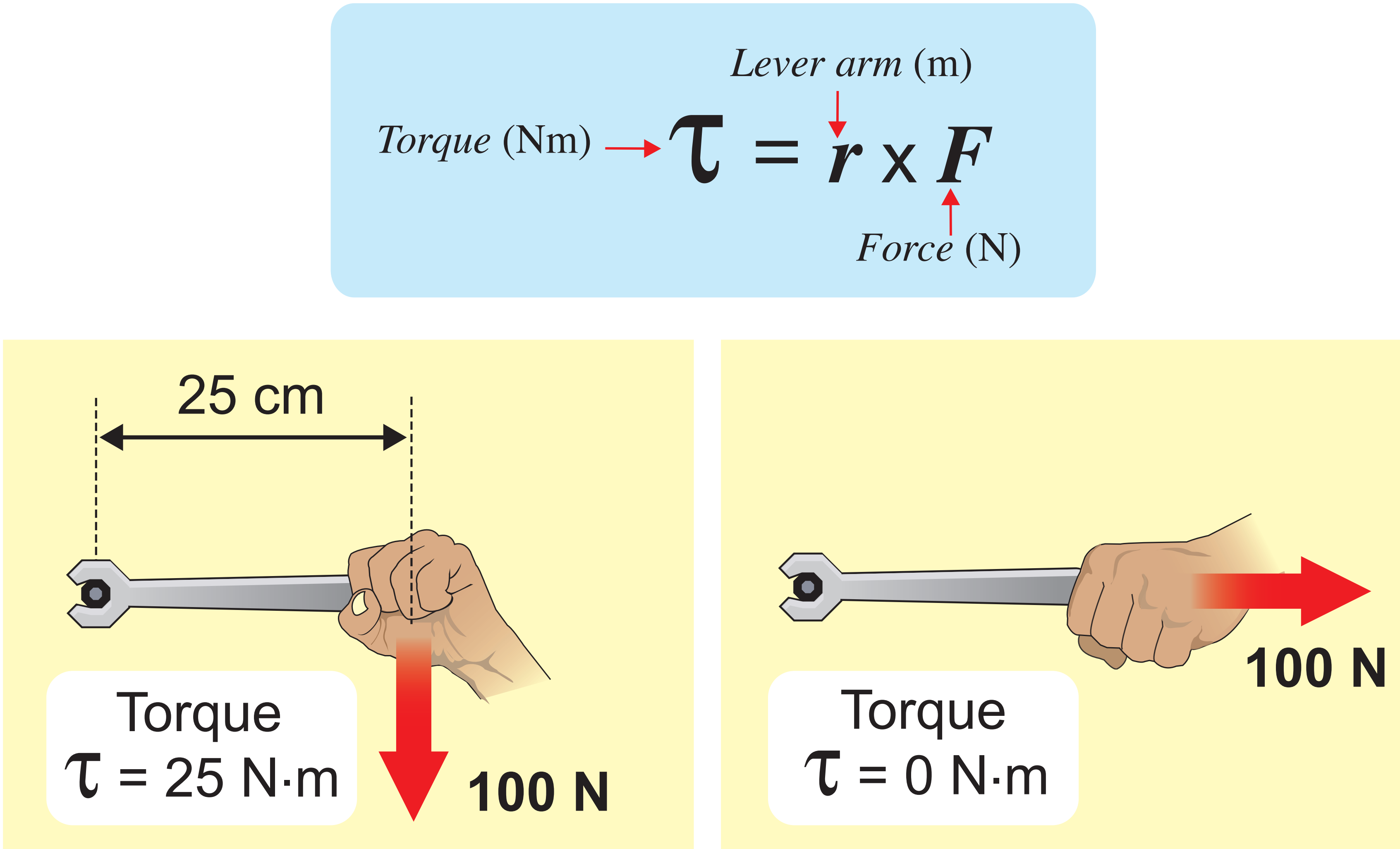
Friction Forces







Torque



Lever arm (m)
Torque (Nm) → τ = r x F
Force (N)
25 cm
Torque
τ = 25 N·m
100 N
Torque
τ = 0 N·m
100 N

Horizontal Distance

Projectile motion

Horizontal velocity (m/sec)

Distance (m) → $d_x = v_x t$ ← *Time* (sec)

Vertical Distance

Projectile motion

Vertical distance (m) → $d_y = 4.9t^2$

Time (seconds)

Vertical Velocity

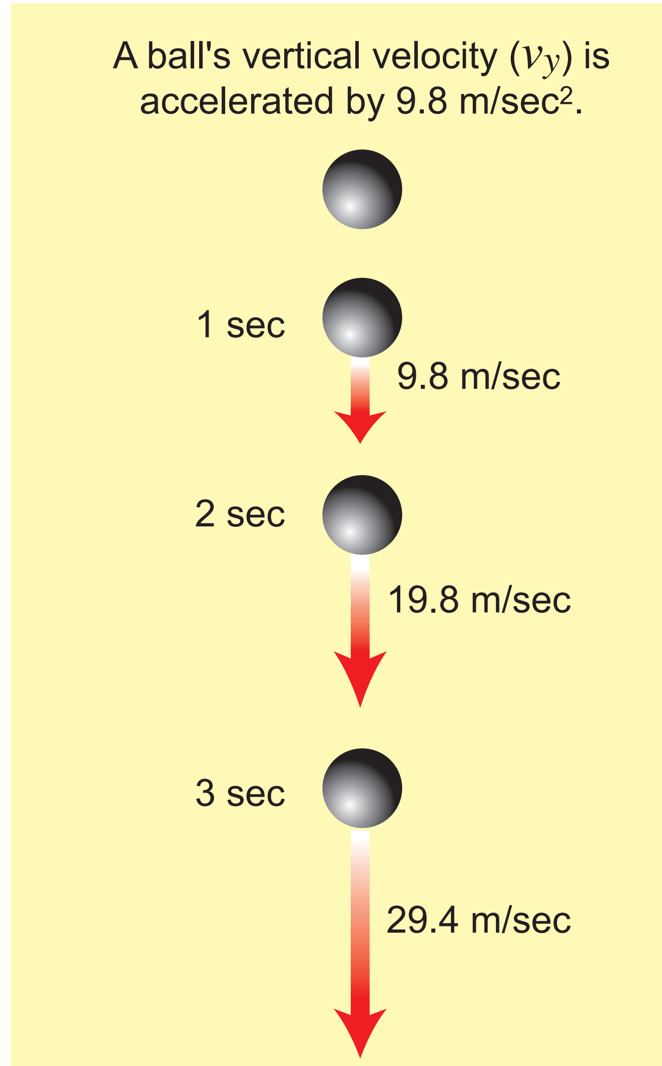
Projectile motion

Vertical velocity (m/sec, downward)

Acceleration due to gravity (m/sec²)

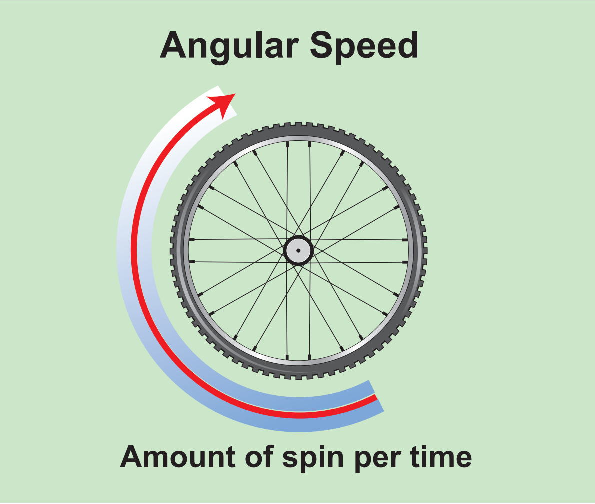
$$v_y = gt$$

Time (sec)



Angular Speed

$$\textit{Angular speed} = \frac{\text{rotations or degrees}}{\text{time}}$$

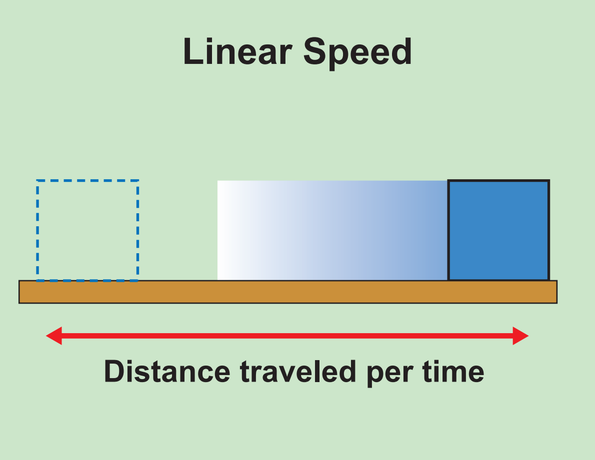


Linear Speed

From angular speed

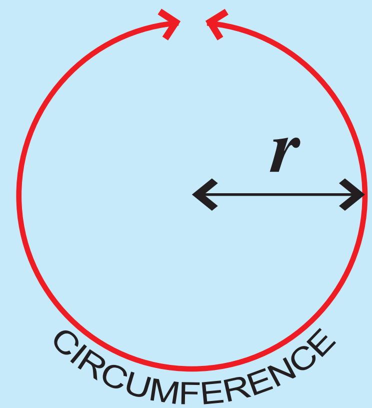
$$v = \frac{2\pi r}{t}$$

- *Linear speed* (m/sec) → v
- *Radius* (meters) → r
- *Time for one revolution* (seconds) → t

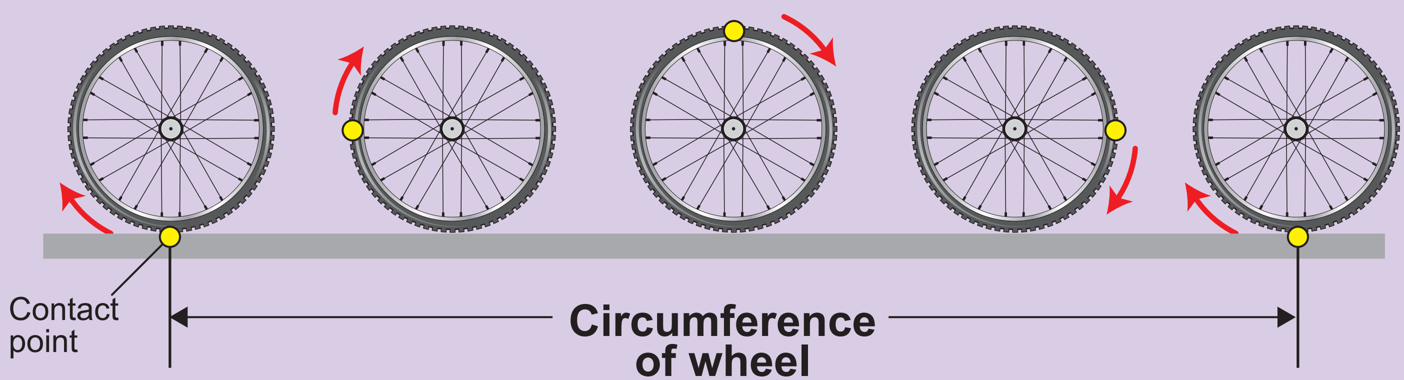


Circumference of a Circle

Circumference (m) → $C = 2\pi r$ ← *Radius* (m)



A wheel moves forward one circumference in one rotation



Law of Universal Gravitation

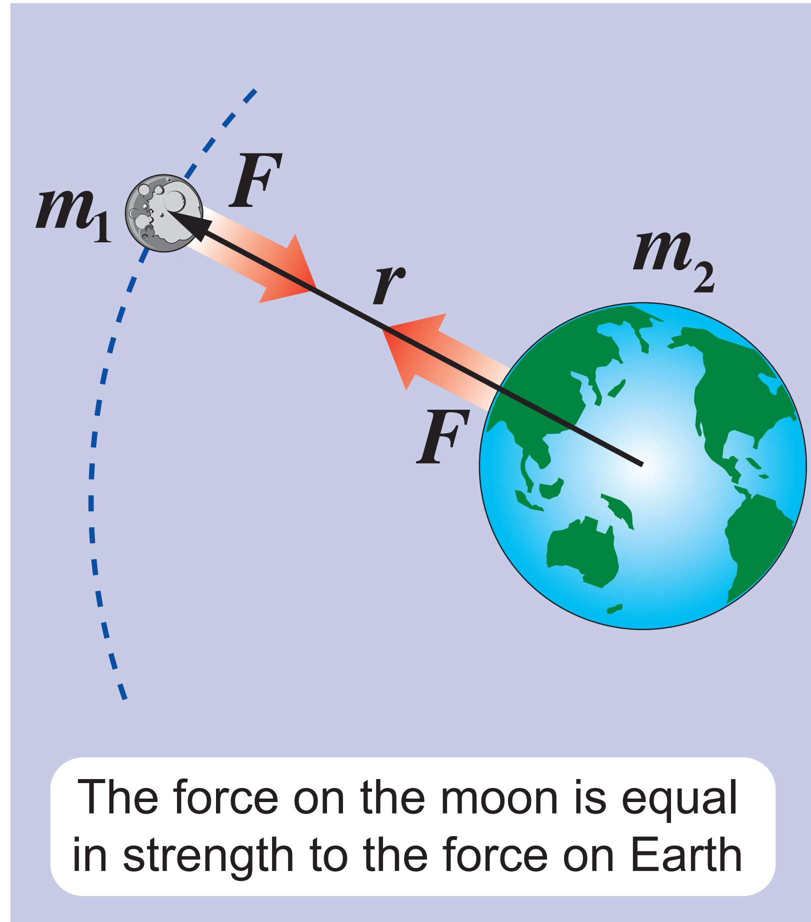
Gravitational constant (6.67×10^{-11} $N{\cdot}m^2/kg^2$)

Mass 1, Mass 2 (kg)

Force

$$F_g = G\frac{m_1 m_2}{r^2}$$

Distance between masses squared (m)



Center of Mass vs. Center of Gravity