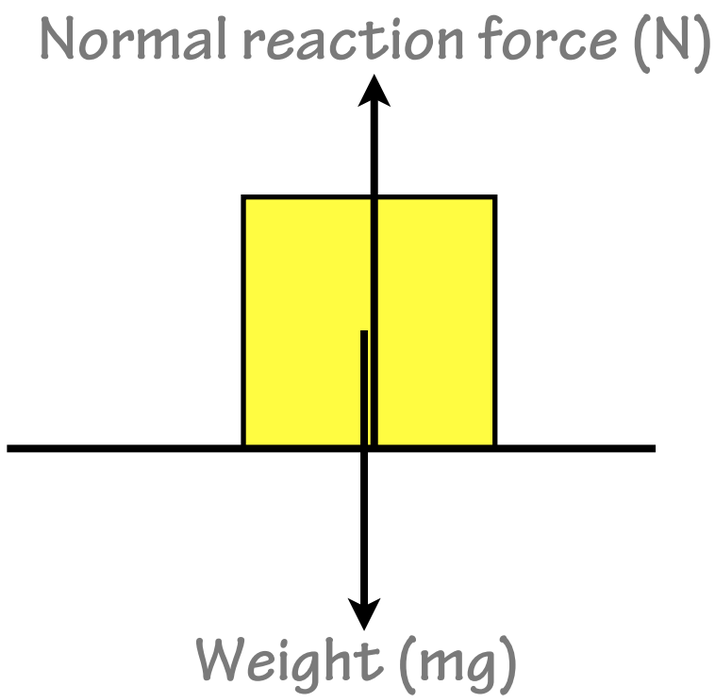
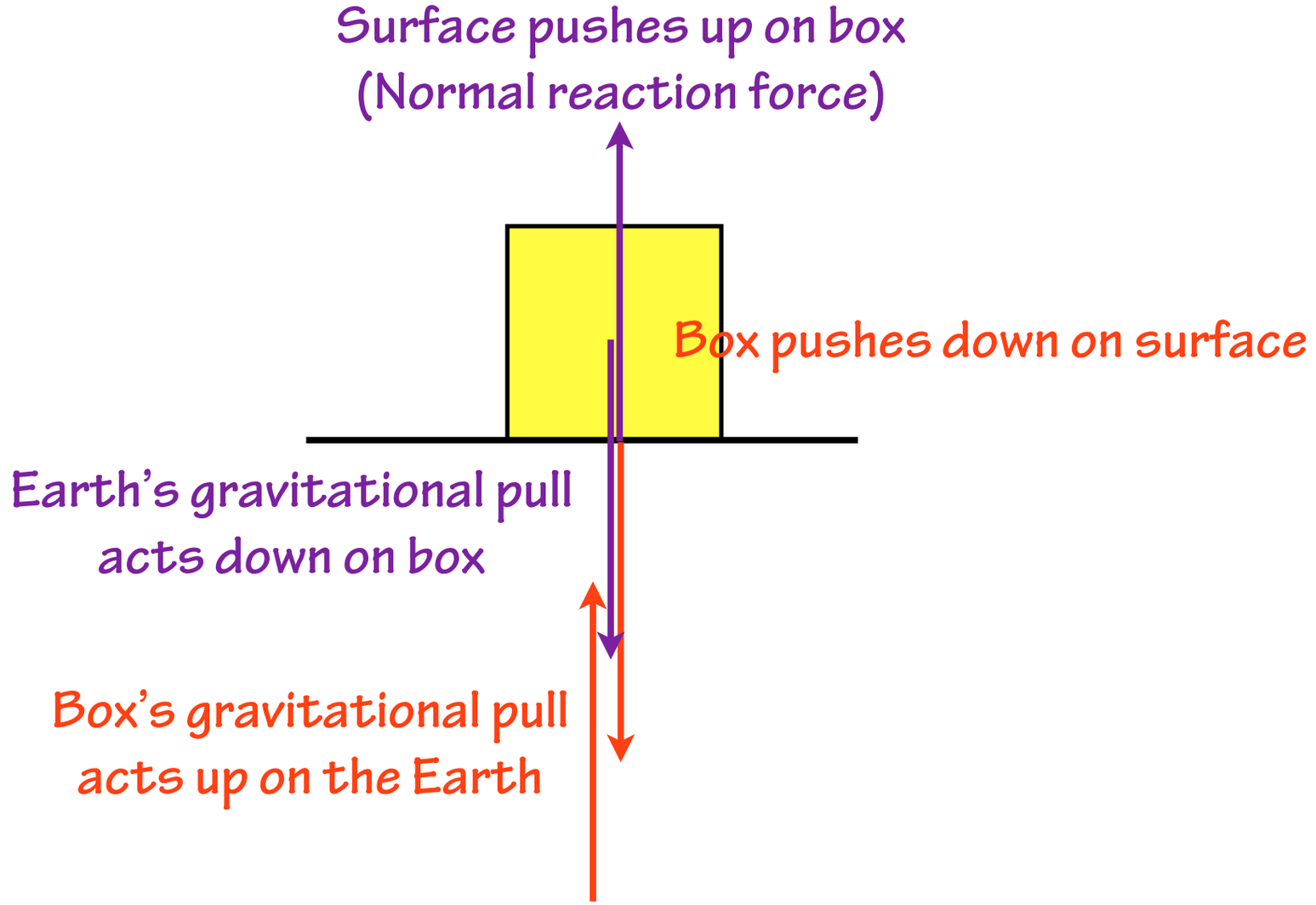
# Calculating forces

- Gravity & Newton's third law
- Tension & pulleys
- Car towing a trailer
- Inclined planes

# Gravity & Newton's third law

- The forces on a stationary object are not an action reaction pair.
- (Action reaction pairs act on different objects).
- **The Earth pulls down on the box. The box pulls up on the Earth.**
- **The box pushes down on the surface (contact force). The surface pushes up on the box.**



# Tension & pulleys

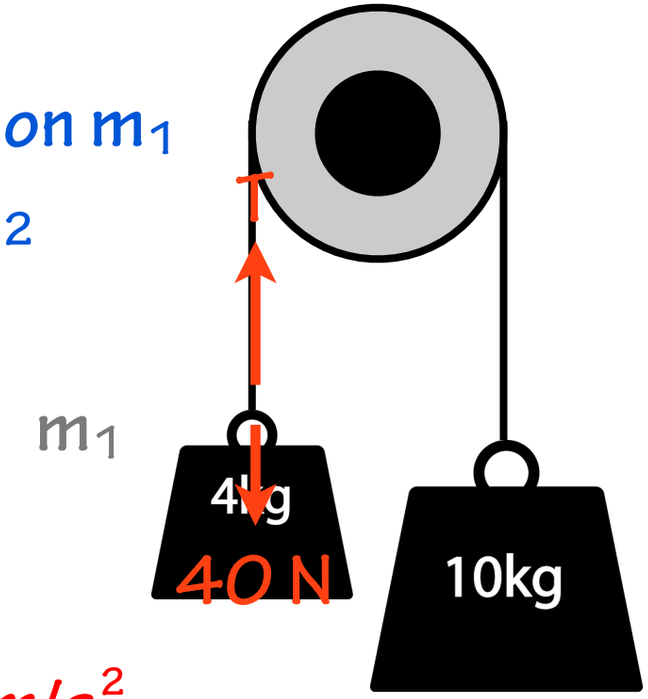
- Two weights on a pulley: 4 kg & 10 kg.
- What is the acceleration of the system?
- What is the tension in the string?

$$a = \frac{\Sigma F}{m} = \frac{100\,\text{N} - 40\,\text{N}}{10\,\text{kg} + 4\,\text{kg}}$$

$$a = \frac{60\,\text{N}}{14\,\text{kg}}$$

$$a = \frac{g(m_2 - m_1)}{(m_2 + m_1)}$$

Tension: pulls up on $m_1$ & against $m_2$




$a = 4.3\ \text{m/s}^2$

$\Sigma F = m_1 a = T - m_1 g$

$T = m_1 a + m_1 g$

$$T = m_1(g + a)$$

$\sum F = 4.0\,\text{kg} \times 4.3\,\text{m/s}^2$

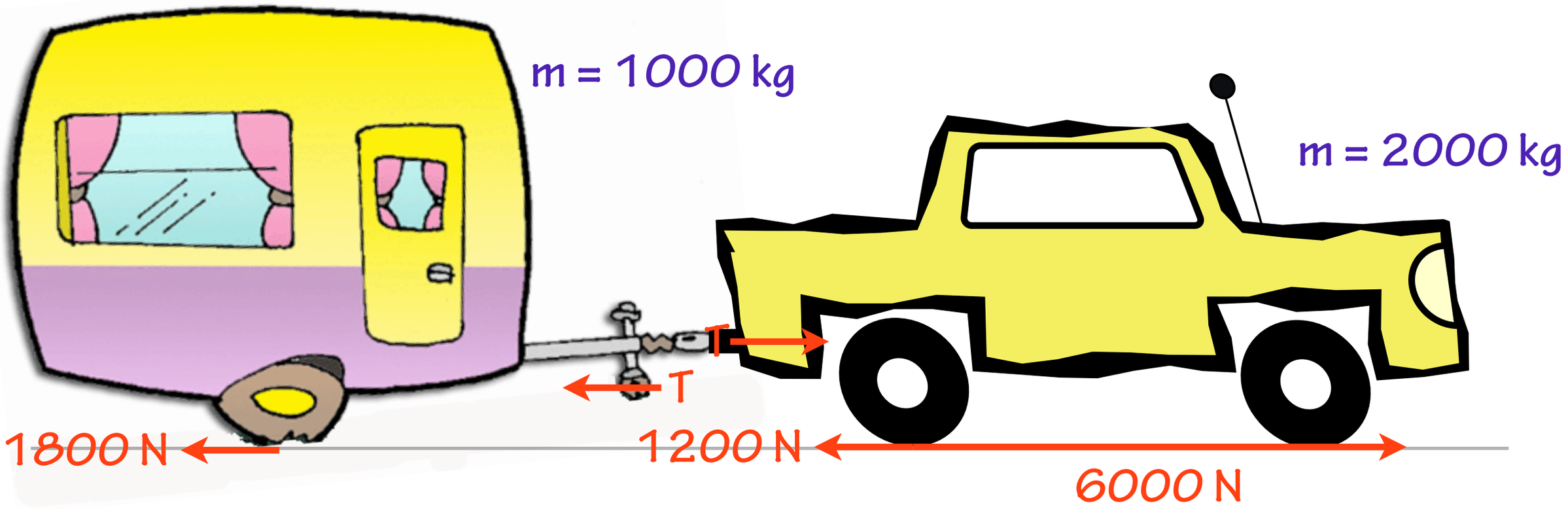
$= 17\,\text{N}$

$m_2$

$T = (4.0\,\text{kg} \times 4.3\,\text{m/s}^2) + 40\,\text{N} = 57\,\text{N}$

# Car towing a trailer

- What is the acceleration?
- What is the tension force pulling forward on the trailer?




$$a = \frac{6000\,\text{N} - 3000\,\text{N}}{3000\,\text{kg}}$$

$$a = \frac{3000\,\text{N}}{3000\,\text{kg}}$$

$$a = 1.0\,\text{m/s}^2$$

**Trailer:**

$$\sum F = ma = 1000\text{kg} \times 1.0\,\text{m/s}^2$$

$$\sum F = 1000\text{N}$$

$$1000\text{N} = T - 1800\text{N}$$

$$T = 2800\text{N (forward)}$$

**Car:**

$$\sum F = ma = 2000\text{kg} \times 1.0\,\text{m/s}^2$$

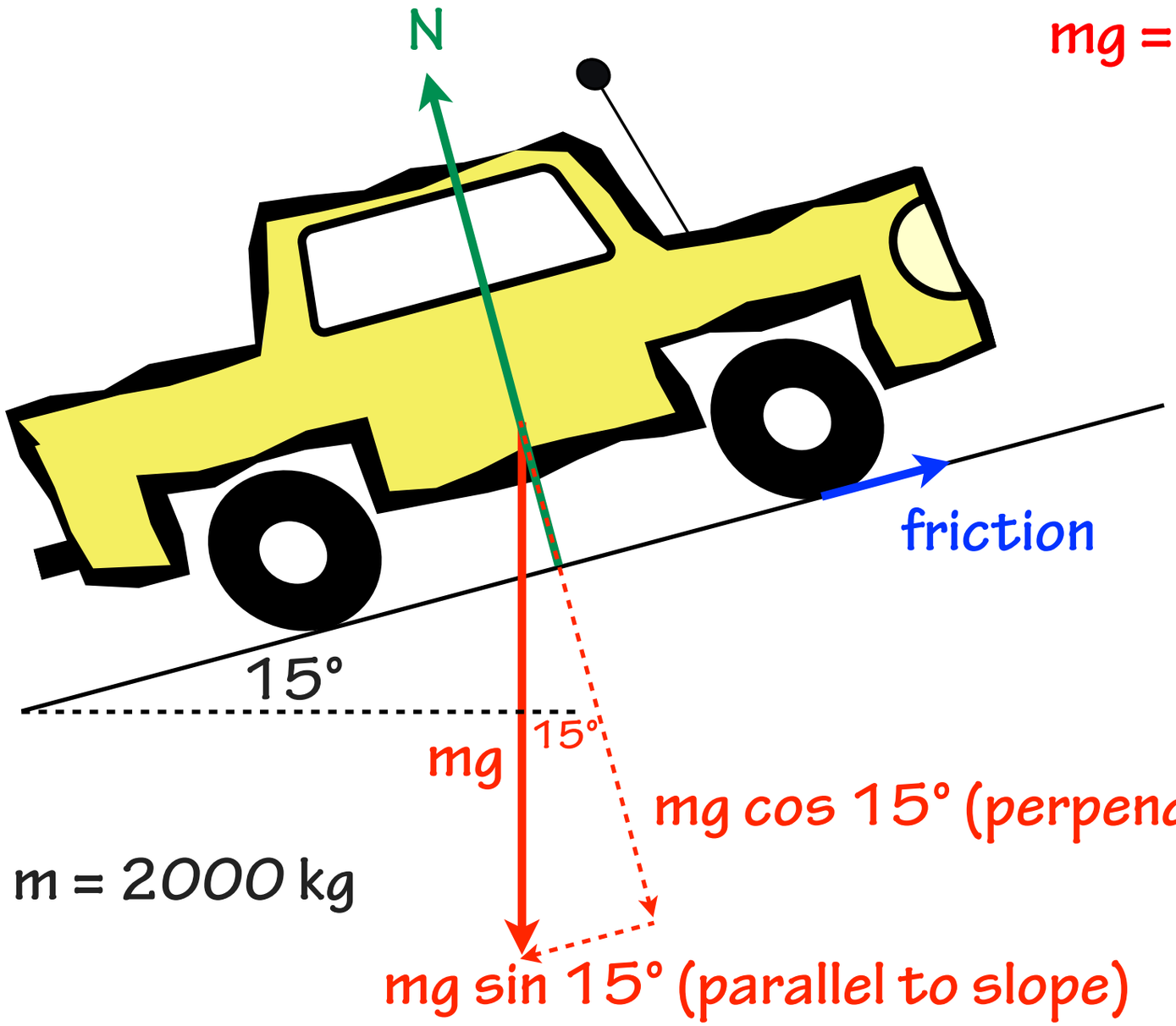
$$\sum F = 2000\text{N}$$

$$2000\text{N} = 6000\text{N} - 1200\text{N} - T$$

$$T = 2800\text{N (back)}$$

# Inclined planes

- An object at rest on an inclined plane has all forces adding to zero.
- The weight force (acting straight down) can be resolved into two components.




$mg = 2000\ kg \times 10\ N/kg = 20{,}000\ N$

$mg = 20kN$

$N = mg\cos\theta$

$N = 20\ kN \times \cos 15°$

$N = 19.3\ kN$

$Friction = mg\sin\theta$

$Friction = 20\ kN \times \sin 15°$

$Friction = 5.2\ kN$