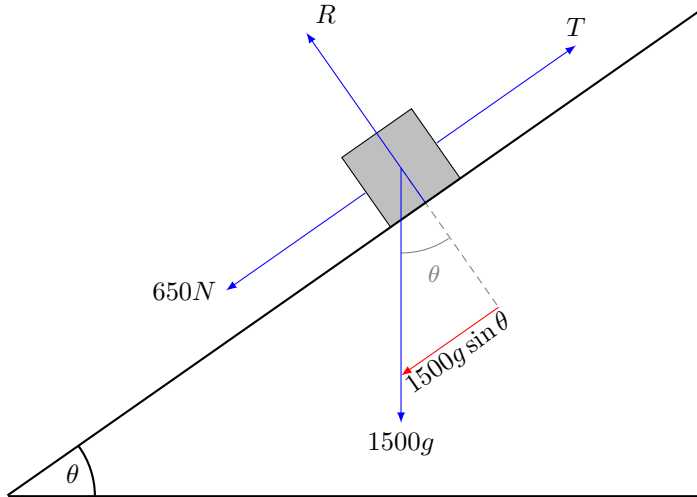


# Dynamics

## Dynamics Example - $F=ma$ on a slope

A car of mass  $1500 \text{ kg}$  is moving up a straight road, which is inclined at an angle  $\theta$  to the horizontal, where  $\sin \theta = \frac{1}{14}$ . The resistance to the motion of the car from non-gravitational forces is constant and is modelled as a single constant force of magnitude  $650 \text{ N}$ . The car's engine is working at a rate of  $30 \text{ kW}$ . Find the acceleration of the car at the instant when its speed is  $15 \text{ ms}^{-1}$ .

**Draw a diagram to represent the question**



**Apply Newton's Second Law ( $F=ma$ )**

$$T - 650 - 1500g \sin \theta = 1500a$$

**Use  $\text{Power} = \text{Force} \times \text{Velocity}$**

$$30,000 = T \times 15$$

$$T = \frac{30,000}{15} = 2000$$

**Solve, substituting power result into Newton's Second Law result**

$$2000 - 650 - 1500 \times 9.8 \times \frac{1}{14} = 1500a$$

$$a = \frac{2000 - 650 - 1500 \times 9.8 \times \frac{1}{14}}{1500} = 0.2$$

## Dynamics Example - Momentum and Impulse

A ball of mass  $0.5 \text{ kg}$  is moving with velocity  $(10\mathbf{i} + 24\mathbf{j}) \text{ ms}^{-1}$  when it is struck by a bat. Immediately after the impact the ball is moving with velocity  $20\mathbf{i} \text{ ms}^{-1}$ .

Find the magnitude of the impulse of the bat on the ball

**Apply the impulse formula**

$$I = m(v - u)$$

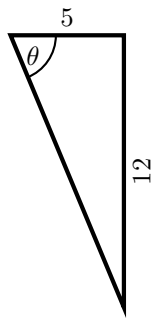
$$I = 0.5(20\mathbf{i} - (10\mathbf{i} + 24\mathbf{j})) = \underline{5\mathbf{i} - 12\mathbf{j}}$$

**Find the magnitude**

$$I = \sqrt{5^2 + (-12)^2} = \underline{13 \text{ N s}}$$

Find the size of the angle between the vector  $i$  and the impulse exerted by the bat on the ball

**Draw diagram to show vector**



**Use trigonometry to find angle**

$$\theta = \arctan\left(\frac{12}{5}\right) = 67.4^\circ$$

Find the kinetic energy lost by the ball in the impact

$$\Delta E_k = E_{k2} - E_{k1}$$

$$\Delta E_k = \frac{1}{2} \times 0.5 \times 20^2 - \frac{1}{2} \times 0.5 \times (10^2 + 24^2) = -69 \text{ J}$$