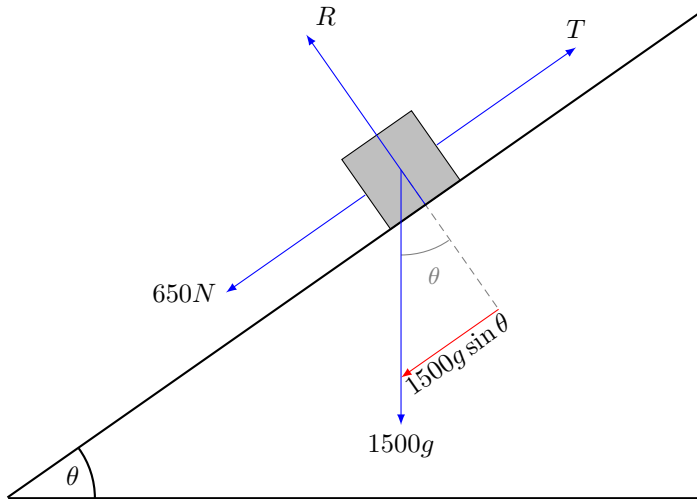


Dynamics

Dynamics Example - $F=ma$ on a slope

A car of mass 1500 kg is moving up a straight road, which is inclined at an angle θ 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 N . The car's engine is working at a rate of 30 kW . Find the acceleration of the car at the instant when its speed is 15 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 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

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

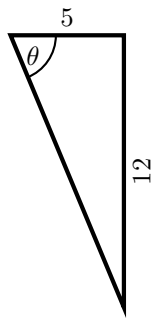
$$I = 0.5(20\mathbf{i} - (10\mathbf{i} + 24\mathbf{j})) = \underline{5\mathbf{i} - 12\mathbf{j}}$$

Find the magnitude

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

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

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

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