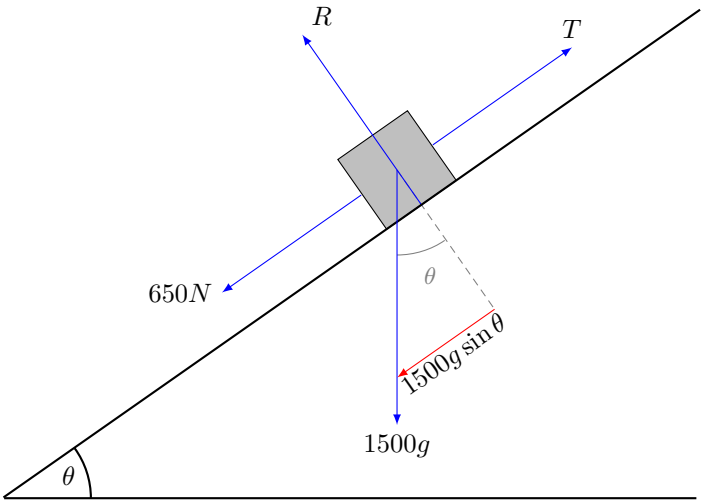
Dynamics

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 $15ms^{-1}$.

Draw a diagram to represent the question



Apply Newton's Second Law (F=ma)

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

Use Power=Force $\times$ Velocity

$30,000 = T \times 15$

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

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

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

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

Dynamics Example - Momentum and Impulse

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

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

Apply the impulse formula

$I = m(v - u)$

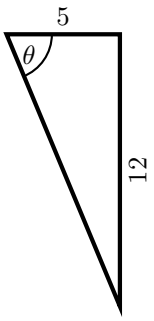
$I = 0.5(20\mathbf{i} - (10\mathbf{i} + 24\mathbf{j})) = \underline{5\mathbf{i} - 12\mathbf{j}}$

Find the magnitude

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

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

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

Find the kinetic energy lost by the ball in the impact

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

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