Newton's Laws of Motion

Starter

1. **(Review of last lesson)** A lift travels vertically upwards from rest at floor A to rest at floor B, which is 20 m above A, in three stages as follows. Firstly, the lift accelerates from rest at A at 2 m/s² for 2 s; secondly, it travels at a constant speed; thirdly it slows down uniformly at 4 m/s² coming to rest at B. Find how long the journey from floor A to floor B takes.

Notes

Newton's first law

"Every object remains in a state of rest or of uniform motion in a straight line unless acted upon by a force."

Newton's second law

"When a force of F newtons acts on an object of mass m kg, the acceleration a m/s² is given by $F = ma$."

$$F = ma$$

Units: Force is in Newtons when mass is in kg and acceleration is in m/s².

E.g. 1 A force of 420 N acts on a block, causing an acceleration of 10.5 m/s². Assuming that no other force acts on the block, find its mass.

N.B. Questions can include SUVAT equations.

E.g. 2 A body of mass 2 kg accelerates uniformly from 3 m/s to 23 m/s in 4 seconds. Find the force acting on the body.

Vector form of Newton's second law

Force and acceleration are vectors but mass is a scalar so $\mathbf{F} = m\mathbf{a}$

E.g. 3 An object of mass 5 kg has an acceleration of $\begin{pmatrix} 3 \\ -4 \end{pmatrix}$ ms^{-2}. Find:

(a) the force vector, $\mathbf{F}$,
(b) the magnitude of the force
(c) the direction of the force.

N.B. The direction of a vector is the angle it makes with the positive $x-$axis.

E.g. 4 A force of magnitude of 104 N acts on a body. Given that the acceleration is $\begin{pmatrix} -12 \\ 5 \end{pmatrix}$ ms^{-2}, find the mass of the body.

Video: Newton's 2nd law

Solutions to Starter and E.g.s

Exercise
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Summary
Newton's second law in 1-dimension: $F = ma$
Newton's second law in 2- or 3-dimensions: $\mathbf{F} = m\mathbf{a}$