Section 2: Applying Newton's second law

Notes and Examples

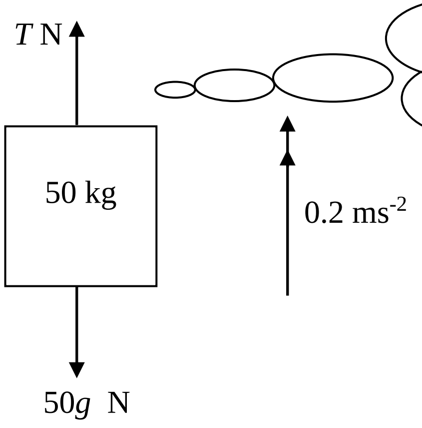
These notes contain subsections on
- Using Newton's second law
- The vector form of Newton's second law

Using Newton's second law

Here are some examples involving the use of Newton's second law, to give you ideas on how to approach these types of problems.

Example 1
A concrete block of mass 50 kg is lifted up the side of a building. The acceleration of the block is 0.2 ms^{-2}. Find the force in the rope.

Solution



> The forces are
> - the weight, 50*g* N, acting downwards
> - the tension in the rope, *T* N, acting upwards

Resultant force = mass × acceleration

> The block is moving up, so let up be positive.

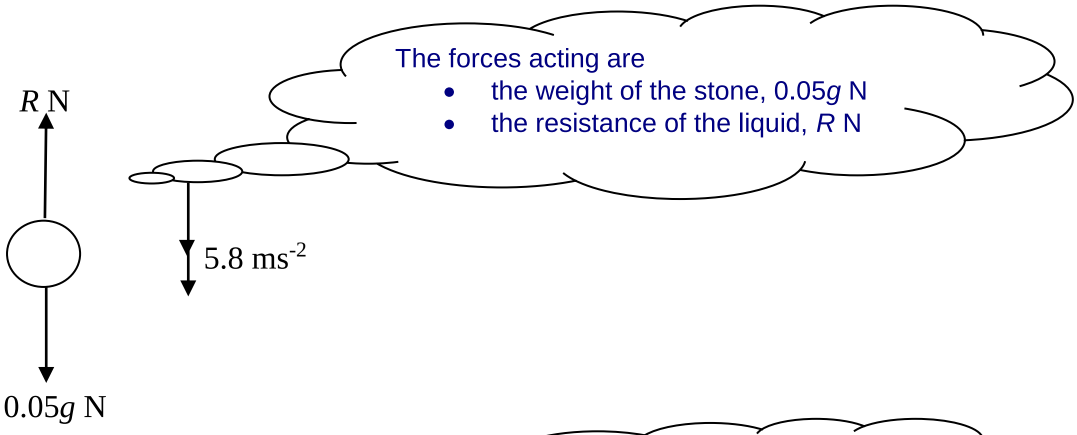
$$T - 50g = 50 \times 0.2$$
$$T = 490 + 10$$
$$T = 500$$

> 490 = 50 × 9.8; always use *g* = 9.8 unless instructed otherwise in the question

The tension in the rope is 500 N.

Example 2
A stone of mass 50 grams is dropped into some liquid and falls vertically through it with an acceleration of 5.8ms^{-2}. Find the force of resistance acting on the stone.

Solution

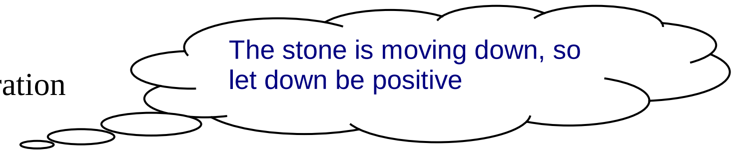


Using resultant force = mass × acceleration

$0.05g - R = 0.05 \times 5.8$

$0.49 - 0.29 = R$

$R = 0.2$



So the resistance force acting on the stone is 0.2 N.

Example 3

A car of mass 700 kg is brought to rest in 7 seconds from a speed of 20 ms^{-1}. What constant force is necessary to produce this deceleration?

Solution

The only force acting is the decelerating force.
The relationship:

Resultant force = mass × acceleration

cannot be used immediately as there are two unknowns, but there is sufficient information to calculate the acceleration, using the equations of motion.

$u = 20\ \text{ms}^{-1}$
$v = 0\ \text{ms}^{-1}$
$a = ?$
$s = ?$
$t = 7$ s

Using $v = u + at$

$0 = 20 + 7a$

$a = \frac{-20}{7}\ \text{ms}^{-2}$

So, using Resultant force = mass × acceleration:

$F = 700 \times \frac{20}{7}$

$F = 2000$

So the decelerating force is 2000 N.

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The vector form of Newton's 2nd law

If information is given in component form, it is possible simply to apply Newton's 2nd Law in vector form to the problem.

Remember that when working in vector form, force and acceleration are both vectors, but mass is not. So Newton's 2nd law can be written as

$$\mathbf{F} = m\mathbf{a}$$

or in handwriting: $\underline{F} = m\underline{a}$

This is shown in the following example.

Example 2
Two forces of $3\mathbf{i} + 2\mathbf{j}$ and $5\mathbf{i} - 3\mathbf{j}$ act on a particle of mass 10 kg.

(i) What is the acceleration of the particle?

(ii) What additional force must act on the particle to give it an acceleration of $2\mathbf{i} + \mathbf{j}$?

Solution

(i) The resultant force on the particle is $(3\mathbf{i} + 2\mathbf{j}) + (5\mathbf{i} - 3\mathbf{j}) = 8\mathbf{i} - \mathbf{j}$.
Newton's 2nd law: $8\mathbf{i} - \mathbf{j} = 10\mathbf{a}$
$\mathbf{a} = 0.8\mathbf{i} - 0.1\mathbf{j}$

Notice that the acceleration is a vector. Remember that in handwriting you must underline vectors.

(ii) Let the additional force be $\mathbf{F}$.
$8\mathbf{i} - \mathbf{j} + \mathbf{F} = 10(2\mathbf{i} + \mathbf{j})$
$\mathbf{F} = 20\mathbf{i} + 10\mathbf{j} - (8\mathbf{i} - \mathbf{j})$
$\mathbf{F} = 12\mathbf{i} + 11\mathbf{j}$