

Forces in Equilibrium

Starter

1. **(Review of last lesson)** A balloon of mass 1400 kg is descending vertically with an acceleration of 2 m/s². Find the upward force being exerted on the balloon by the atmosphere.

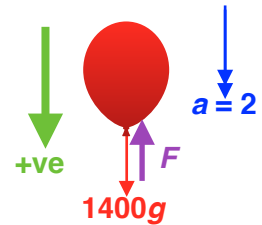
Working: Let F be the upward force being exerted on the balloon by the atmosphere.

$$F = ma: \quad 1400g - F = 1400 \times 2$$

$$1400g - 1400 \times 2 = F$$

$$F = 10920$$

The upward force being exerted on the balloon by the atmosphere is 10920 N.



2. **(Review of last lesson)** A rope with a bucket attached to the end is used to raise water from a well. The mass of the empty bucket is 1.2 kg and it can raise 10 kg of water when full. Taking g as 9.8 m/s² find the tension in the rope when:

- (a) the empty bucket is lowered with an acceleration of 2 m/s²
 (b) the full bucket is raised with an acceleration of 0.3 m/s².

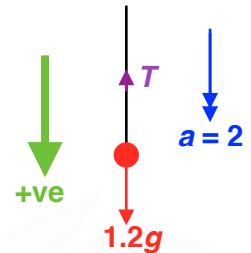
Working: (a) $F = ma:$

$$1.2g - T = 1.2 \times 2$$

$$1.2g - 1.2 \times 2 = T$$

$$T = 9.36 \text{ N}$$

The tension in the rope is 9.36 N



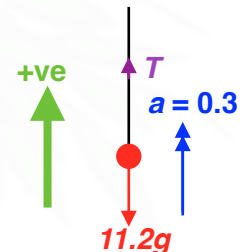
(b) $F = ma:$

$$T - 11.2g = 11.2 \times 0.3$$

$$T = 11.2 \times 0.3 + 11.2g$$

$$T = 113.12 \text{ N}$$

The tension in the rope is 113 N (3 s.f.)



- E.g. 1** In a tug-o'-war competition, two people on each side are pulling on the rope. The two people on the left are pulling with forces of 35 N and 40 N, while the two on the right pull with forces 32 N and D N. Given that the rope is held in equilibrium, find the value of D .

Working: The forces to the right equal the forces to the left.

$$R(\rightarrow): \quad D + 32 = 35 + 40$$

$$D = 43 \text{ N}$$

- E.g. 2** An object is held in equilibrium by 3 forces: $(3\mathbf{i} + 7\mathbf{j})$ N, $(x\mathbf{i} + y\mathbf{j})$ N and $(-5\mathbf{i} + 2\mathbf{j})$ N. Find the value of x and y .

Working: The sum of the forces is zero.

$$(3\mathbf{i} + 7\mathbf{j}) + (x\mathbf{i} + y\mathbf{j}) + (-5\mathbf{i} + 2\mathbf{j}) = 0$$

$$\mathbf{i}: \quad 3 + x - 5 = 0 \quad \Rightarrow \quad x = 2$$

$$\mathbf{j}: \quad 7 + y + 2 = 0 \quad \Rightarrow \quad y = -9$$

$$x = 2, y = -9$$

Exercise

p500 21E Qu 1ac, 2ac, 3i, 4-8, 11-12

