Gravity and Weight

Starter

1. **(Review of last lesson)** A train of mass 20 tonnes accelerates under a driving force of 50000 N. Resistance to motion is 28000 N. Starting from rest, how long does it take to travel 1 km, given that it accelerates for the whole time.
   Remember: 1 tonne $\equiv 1000$ kg

Assume the acceleration due to gravity g is 9.8 m/s^2.

2. Find the weight of a body of mass 5 kg.

3. What is the mass of a sack of potatoes of weight 147 N?

4. What is the weight of a tennis ball of mass 60 grams?

5. On the moon the acceleration due to gravity is 1.2 m/s^2. What would be the answers above?

Notes

Mass vs weight

The mass of an object is the same wherever the object is whereas weight is a force and depends on which planet or moon you are stood on.

$$\text{Weight} = \text{mass} \times g \quad \text{where } g = \text{acceleration due to gravity (on Earth } \approx 9.8 \text{ m/s}^2\text{)}$$

A question will often use the phrase “light, inextensible string” meaning the weight of the string is negligible and does not extend under load.

Key steps

- Draw a diagram showing all the forces.
- Decide which direction is positive (it is suggested the direction of motion is positive).

Mass at the end of a string

What happens when tension > mass? What direction should be positive: up or down?

Accelerate upwards; up is positive

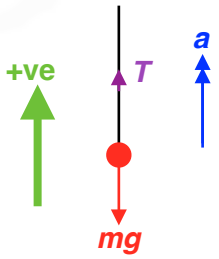
What happens when tension < mass?

Accelerate downwards; down is positive

Accelerating upwards vs. accelerating downwards

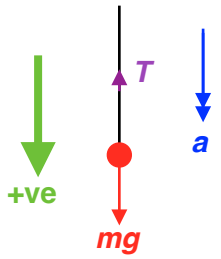
Accelerating *upwards*

Positive direction ***upwards***



Accelerating *downwards*

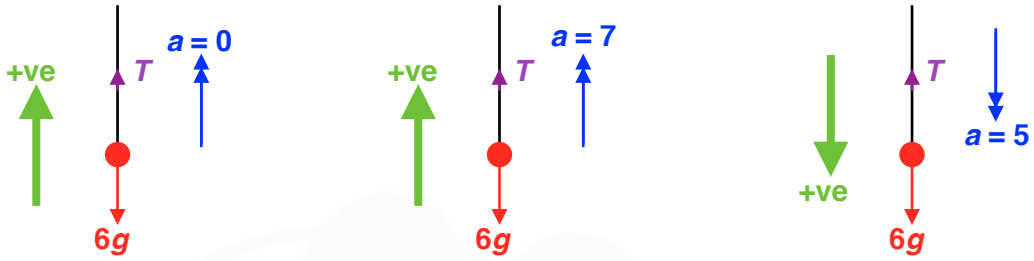
Positive direction ***downwards***



Using $F = ma$: $T - mg = ma$ $mg - T = ma$

E.g. 1 A mass of 6 kg is moving vertically at the end of a light string. Find the tension in the string when the mass has an acceleration of:

(a) zero (b) 7 m/s² upwards (c) 5 m/s² downwards.



Working: (a) $F = ma$: $T - 6g = 0$

$T = 58.8$ N

Or, there is no acceleration so we could resolve vertically

$R(\uparrow)$: $T = 6g$

$T = 58.8$ N

(b) ***Upwards is positive***

$F = ma$: $T - 6g = 6 \times 7$

$T = 6 \times 7 + 6g$

$T = 100.8$ N

E.g. 2 The tension in a string, which has a particle of mass m kg attached to its lower end, is 70 N. Find the value of m if the particle has:

(a) an acceleration of 3 m/s² upwards

(b) an acceleration of 9 m/s² downwards

(c) a constant velocity of 4 m/s upwards

(d) a constant velocity of 4 m/s downwards.

Working: (a) ***Upwards is positive***

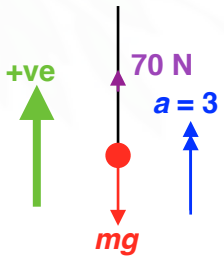
$F = ma$: $70 - mg = m \times 3$

$70 = m(3 + g)$

$m = \dfrac{70}{3 + g}$ N

$m = 5.46875$

The mass of the particle is 5.47 kg (3 s.f.)



Video: Gravity vs. weight

Solutions to Starter and E.g.s

Exercise

p497 21D Qu 1i, 2i, 3i, 4-13

Summary

Weight = mass $\times g$ where g = acceleration due to gravity (on Earth ≈ 9.8 m/s²)

Key steps

- Draw a diagram showing all the forces.
- Decide which direction is positive (it is suggested the direction of motion is positive).

Accelerating upwards: $T - mg = ma$

Accelerating downwards: $mg - T = ma$