Test answers - Forces and Newton's laws

Year: Year 12 · Duration: 60 minutes · /20

Answer to Question 1 (4 marks)

The forces are at right angles, so the magnitude comes from Pythagoras and the angle from $\tan\theta = \dfrac{\text{opposite}}{\text{adjacent}}$.

$\sqrt{81+144} = 15$ N (2). Angle $= \tan^{-1}\left(\frac{9}{12}\right) = 36.9^\circ$ (2).

The resultant is 15 N at 36.9° to the 12 N force (opposite side 9 N, adjacent side 12 N).

The resultant lies between the two forces, closer to the larger 12 N force.

A labelled sketch of the right-angled triangle of forces earns credit even if the arithmetic slips.

Answer to Question 2 (4 marks)

a. The resultant force is the pull minus the resistance; apply $F = ma$. $30 - 12 = 5a$, $a = 3.6$ m/s^2 (2) The block accelerates at 3.6 m/s^2. The resultant force on the block is 18 N.
b. Use $s = ut + \frac{1}{2}at^2$ with $u = 0$ and $t = 4$. $s = \frac{1}{2} \times 3.6 \times 16 = 28.8$ m (2) The block travels 28.8 m in 4 s.

Draw a force diagram first: 30 N forward, 12 N backward, and the weight $5g$ balanced by the normal reaction. Using 30 N alone in $F = ma$ gives the wrong answer 6 m/s^2.

Answer to Question 3 (4 marks)

The 4 kg particle moves down and the 2 kg particle moves up, with the same acceleration; write $F = ma$ for each.

$4g - T = 4a$ and $T - 2g = 2a$ (1). Add: $2g = 6a$, $a = 3.27$ m/s^2 (1). $T = 2(g + a) = 26.1$ N (2).

Substituting into $T - 2g = 2a$ gives $T = 2(9.8 + 3.27) = 26.1$ N. So $a = 3.27$ m/s^2 and $T = 26.1$ N.

As expected, the tension lies between the two weights, $2g = 19.6$ N and $4g = 39.2$ N.

Here $a = \frac{g}{3}$ exactly, and $9.8 \div 3 = 3.27$ to 3 s.f.

Answer to Question 4 (4 marks)

On a smooth slope, resolve perpendicular to the slope (no acceleration) and along the slope (Newton's second law).

$R = 3g\cos 40^\circ = 22.5$ N (2). $a = g\sin 40^\circ = 6.30$ m/s^2 (2).

So the normal reaction is 22.5 N and the block accelerates down the slope at 6.30 m/s^2, whatever its mass.

The normal reaction is less than the weight $3g = 29.4$ N because it only balances the component of the weight perpendicular to the slope.

Answer to Question 5 (4 marks)

a. Treat lorry and trailer as one body; the tension is internal, and the total resistance is 2 000 N. $8000 - 2000 = 4000a$, $a = 1.5$ m/s^2 (2) The acceleration is 1.5 m/s^2.
b. Consider the trailer alone: the tension pulls it forward and its resistance acts backwards. Trailer: $T - 500 = 1000 \times 1.5$, $T = 2000$ N (2) The tension in the tow-bar is 2 000 N.

Check with the lorry alone, where the tension acts backwards:
$8000 - 1500 - 2000 = 4500 = 3000 \times 1.5$ ✓.