

Solutions

2.1 Scalars: speed, work, distance, energy. Vectors: velocity, weight, momentum, displacement.

2.2 Horizontal: $F_h = F \cos \theta = 60 \text{ N} \times \cos 25^\circ = 54 \text{ N}$. Vertical: $F_v = F \sin \theta = 60 \text{ N} \times \sin 25^\circ = 25 \text{ N}$.

2.3 $R = \sqrt{F_x^2 + F_y^2} = \sqrt{30^2 + 40^2} \text{ N} = 50 \text{ N}$; $\tan \theta = \frac{40}{30}$ so $\theta = 53^\circ$ east of north.

2.4

(a) $\vec{W} + \vec{T}_1 + \vec{T}_2 = \vec{0}$. (b) Drawn nose to tail, the three force arrows form a **closed triangle**; any side's length gives its force on the chosen scale.

2.5 Both coins have the same initial vertical velocity (zero) and fall the same height under g , and the vertical motion is independent of the horizontal motion – so the times are equal; coin Q travels further because its horizontal velocity is larger for the same time.

3.1 C. The forces are perpendicular, so the resultant is the hypotenuse. A adds the roots separately; B adds without squaring; D subtracts the squares.

3.2 C. The vertical motion decides the landing time and is identical for both stones. A and B confuse horizontal speed with vertical fall; D names mass, which does not appear in free fall.

3.3 (a) Each wire half pulls up with $T \sin \theta$; equilibrium gives $W = T \sin \theta + T \sin \theta = 2T \sin \theta$. (b) $T = \frac{W}{2 \sin \theta}$: as θ gets smaller, $\sin \theta$ gets smaller, so the tension must **increase** for the same weight.

3.4 (a) $u_v = u \sin \theta = 25 \text{ m s}^{-1} \times \sin 40^\circ = 16.1 \text{ m s}^{-1} \approx 16 \text{ m s}^{-1}$. (b) Known: $u_v = 16.1 \text{ m s}^{-1}$, and at landing $v_v = -16.1 \text{ m s}^{-1}$ (same level). Use $v = u + at$:

$$t = \frac{v_v - u_v}{-g} = \frac{-16.1 \text{ m s}^{-1} - 16.1 \text{ m s}^{-1}}{-9.81 \text{ m s}^{-2}} = 3.3 \text{ s (M1, A1)}$$

(c) $u_h = u \cos \theta = 25 \text{ m s}^{-1} \times \cos 40^\circ = 19.2 \text{ m s}^{-1}$; $s_h = u_h \times t = 19.2 \text{ m s}^{-1} \times 3.3 \text{ s} = 63 \text{ m}$.

(d) A larger angle raises u_v , so the flight is longer, but it lowers u_h ; since distance = $u_h \times t$, the smaller horizontal speed can win, and the distance falls.