

Solutions

2.1 Gravity: $20(9.8)(5 \sin 30^\circ) = 490$ J; friction: $15(5) = 75$ J; total 565 J.

2.2 Maximum speed: $\frac{8000}{500} = 16 \text{ m s}^{-1}$. At 8: driving force = 1000 N, so $1000 - 500 = 1200a$ and $a = 0.417 \text{ m s}^{-2}$ (0.42).

2.3 $\frac{1}{2}(15)^2 = 9.8h$: $h = \frac{112.5}{9.8} = 11.5$ m.

3.1 (a) At constant speed the driving force $F = \frac{P}{V}$ balances resistance plus gravity: $\frac{20000}{V} = 750(9.8)\frac{1}{7} + 200 = 1050 + 200 = 1250$, so $V = 16 \text{ m s}^{-1}$. (b) $\frac{20000}{10} - 1250 = 750a$: $2000 - 1250 = 750a$, $a = 1 \text{ m s}^{-2}$. (c) Work-energy: KE lost = work against gravity + friction: $\frac{1}{2}(750)(10^2) = 750(9.8)(d\frac{1}{7}) + 200d$, i.e. $37500 = 1050d + 200d = 1250d$, so $AB = 30$ m.

3.2 (a) Energy from O to the 11 m point: $\frac{1}{2}m(20)^2 = \frac{1}{2}m(V^2 + (2V)^2) + m(10)(11)$: $200 = \frac{5}{2}V^2 + 110$, so $V^2 = 36$ and $V = 6$ ✓ (components 6 and 12, speed² = 180). (b) Perpendicular to the 60° plane, the velocity makes 30° with the horizontal (below it), so with horizontal component 12 the speed is $\frac{12}{\cos 30^\circ} = 8\sqrt{3}$ and speed² = 192. Energy from O to A: $200 = \frac{1}{2}(192) + 10H = 96 + 10H$, so $H = 10.4$, i.e. 10 m (2 s.f.).

Local review guidance: $\frac{P}{V}$ for the driving force with all three slope terms present; work-energy with resistance over the slope distance and gravity over the height; perpendicular impact converted to a velocity direction before any energy statement. This is authored classroom guidance.