| | | | | |
|---|---|---|---|---|
| **1** | DF = 28000 | B1 | | |
| | [1330 000 = 28000V] | M1 | | For using P = (DF)V |
| | V = 47.5 | A1 | [3] | |
| **2 (i)** | 2.4 = 0.25g cosα | B1 | | |
| | α = 16.3 | B1 | [2] | |
| **(ii)** | [μ = 0.28÷0.96] | M1 | | For using μ = F/R or μ = tanα |
| | Least possible value of μ is 7/24 or 0.292 | A1 | [2] | |
| **3** | | M1 | | For finding the component of the forces in the $x$ direction |
| | X = 5 – 7cos 60° – 3cos 30° (= – 1.098) | A1 | | |
| | | M1 | | For finding the component of the forces in the $y$ direction |
| | Y = 7sin 60° – 3sin 30° – 4 (= 0.5622) | A1 | | |
| | | M1 | | For using $R^2 = X^2 + Y^2$ and tan θ = Y/X |
| | Resultant is 1.23 N and Direction is 152.9° anticlockwise from +ve $x$-axis oe | A1 | [6] | |
| **4** | | M1 | | For using $0 = u^2 - 2gs$ for the upwards motion |
| | For s = 4.05 | A1 | | |
| | Total distance = 4.05 + (3.15 + 4.05) = 11.25 m | B1 | | |
| | $t_{upwards} = 0.9$ | B1 | | |
| | For downwards motion $(3.15 + 4.05) = \frac{1}{2}gt^2 \rightarrow t = 1.2$ | B1 | | |
| | Time taken is 2.1 s | B1 | [6] | |

| | | | | |
|---|---|---|---|---|
| | **Alternative Mark Scheme for final 3 marks** | | | |
| | $[-3.15 = 9T + \frac{1}{2}(-g)T^2]$ | M1 | | For using $s = ut + \frac{1}{2}at^2$ for the total displacement and time |
| | $[100t^2 - 180t - 63 = 0]$ | M1 | | For solving a quadratic equation for the total time T |
| | $(10T - 21)(10T + 3) = 0$ | A1 | | T = 2.1 only |
| **5 (i)** | KE gain = $550v^2$ | B1 | | |
| | PE gain = $1000x$ | B1 | | |
| | $[1800x = 550v^2 + 1000x + 700x]$ | M1 | | |
| | $k = 5.5$ | A1√ | [4] | ft for incorrect coeff(s) of $v^2$ and/or of $x$ |
| **(ii)** | At A $5.5v^2 = 1760 \rightarrow v^2 = 320$ | B1 | | |
| | | M1 | | For using from A, KEgain= WD by DF –WD against R |
| | $550(v^2 - 320) = 1800(x - 1760) - 700(x - 1760)$ | A1 | | |
| | $v^2 = 2x - 3200$ (cwo) | A1 | [4] | AG |
| | **Alternative for part (ii)** $[1800 - 700 = 1100a$ and $5.5v^2 = 1760]$ | M1 | | For applying Newton's 2nd Law to find acceleration along AB **and** for using $kv^2 = x$ to find $v^2$ at A |
| | $a = 1$ and $v^2 = 320$ | A1 | | |
| | $[v^2 = 320 + 2 \times 1 \times (x - 1760)]$ | M1 | | For using $v^2 = u^2 + 2as$ for motion from A to B |
| | $v^2 = 2x - 3200$ | A1 | [4] | |
| **6 (i)** | | M1 | | For using Newton's second law for both particles and eliminating T, or using $(M + m)a = (M - m)g$ |
| | Acceleration is $5\,ms^{-2}$ | A1 | | |
| | | M1 | | For using $s = 0 + \frac{1}{2}at^2$ |
| | Distance is 0.9 m | A1 | [4] | |
| **(ii)** | $\frac{1}{2}\,0.6 \times V = 0.9 \rightarrow V = 3$ | B1√ | | ft distance in (i) |
| | | M1 | | For using $0 = V - g(T - 0.6)$ |
| | T = 0.9 | A1 | [3] | |

| | | | | |
|---|---|---|---|---|
| (iii) | $[s_{up} = \frac{1}{2}\,0.9 \times 3$ and $s_{down} = 0 + \frac{1}{2}g(1.6 - 0.9)^2]$ | M1 | | For using area property in graph or equivalent |
| | Distance upwards is 1.35 m and distance downwards is 2.45 m | A1 | | |
| | h = 1.1 | B1√ | [3] | ft $s_{down} - s_{up}$ |
| 7 (i) | | M1 | | For using $s = ut + \frac{1}{2}at^2$ to find the distance AB, or for using v = u + at to find P's speed at B |
| | $AB = 3 \times 400 + \frac{1}{2}\,0.005 \times 400^2 = 1600$ m (AG) or $v_B = 3 + 0.005 \times 400 = 5\ ms^{-1}$ | A1 | | |
| | $v_B = 3 + 0.005 \times 400 = 5\ ms^{-1}$ or $AB = 3 \times 400 + \frac{1}{2}\,0.005 \times 400^2 = 1600$ m (AG) | B1 | [3] | |
| (ii) | | M1 | | For using $\int_0^{400} v\,dt = 1600$ |
| | $[0.02t^2 - 0.0001t^3/3 + kt]_0^{400} = 1600$ | A1 | | |
| | $400k = 1600 - 0.02 \times 400^2 + 0.0001 \times 400^3 \div 3 \rightarrow$ $k = 4 - 8 + 16/3 = 4/3$ | A1 | | |
| | $[dv/dt = 0.04 - 0.0002t$ (= 0 when t = 200)] | M1 | | For differentiating and solving dv/dt = 0 |
| | $v_{max} = 0.04 \times 200 - 0.0001 \times 200^2 + 4/3$ | A1√ | | ft incorrect k or incorrect value of t from dv/dt = 0 |
| | Maximum speed is $5.33\ ms^{-1}$ | A1 | [6] | |
| (iii) | | M1 | | For using constant speed $5\ ms^{-1} = 1400/T$ |
| | Time taken is 280 s | A1 | | |
| | $[1400 = 4/3 \times 280 + \frac{1}{2}\,280^2 a]$ | M1 | | For using $s = ut + \frac{1}{2}at^2$ to find a |
| | a = 0.0262 | A1 | [4] | |