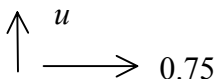
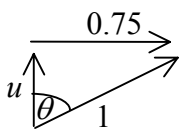
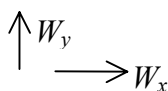
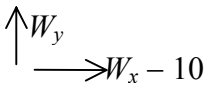
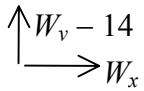
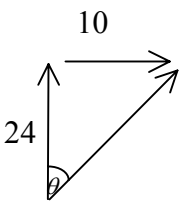
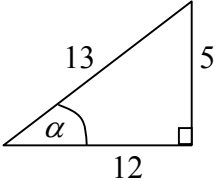


Question Number	Scheme	Marks
1.	<p>Let boy's velocity be </p> <p>Speed = 1 $\Rightarrow 1^2 = u^2 + \frac{9}{16}$, $\therefore u^2 = \frac{7}{16}$ or $u = \frac{\sqrt{7}}{4}$ or 0.661...</p> <p>Time = $\frac{100}{\sqrt{7}/4} = 151.18\dots = 151\text{s}$</p> <p> $\sin \theta = \frac{0.75}{1} \Rightarrow \theta = 48.6$</p> <p>$\therefore$ Bearing is 049° or 048.6°</p>	<p>M1</p> <p>M1 A1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>(6)</p> <p>(6 marks)</p>
2.	<p>Let wind be </p> <p>Relative to A:  From South, $\Rightarrow W_x = 10$</p> <p>Relative to B:  From SW, $\Rightarrow W_y - 14 = W_x \therefore W_y = 24$</p> <p>$\therefore$ Magnitude of $W = \sqrt{10^2 + 24^2} = 26 \text{ km h}^{-1}$</p> <p> $\tan \alpha = \frac{10}{24} \Rightarrow \alpha = 22.6$</p> <p>$\therefore$ Bearing 023° or 022.6°</p>	<p>M1</p> <p>M1, A1</p> <p>M1, A1</p> <p>A1</p> <p>A1</p> <p>(7 marks)</p>

Question Number	Scheme	Marks
3.	$(\downarrow) \quad mg - mkv^2 = ma$ $g - kv^2 = v \frac{dv}{dx}$ $x = \int \frac{v}{g - kv^2} dv$ $x = -\frac{1}{2k} \ln g - kv^2 + c$ $x = 0, v = 0 \Rightarrow 0 = -\frac{1}{2k} + c$ $x = \frac{1}{2k} \ln \left \frac{g}{g - kv^2} \right $ $e^{2kx} = \frac{g}{g - kv^2}$ $kv^2 = g(1 - e^{-2kx})$ $v = \sqrt{\frac{g}{k}(1 - e^{-2kD})}$	<p>M1 A1</p> <p>$v \frac{dv}{dx}$ M1</p> <p>M1</p> <p>M1 A1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>must use D A1</p> <p>(11 marks)</p>

Question Number	Scheme	Marks
4. (a)	<p>P.E.of rod = $mg \times 2a \sin 2\theta$</p> <p>$AC = a \cot \theta$</p> <p>EPE in String = $\frac{1}{2} \times \frac{3}{4} \times \frac{mg}{a} (a \cot \theta - a)^2$</p> <p>Total P.E $V = mg \cdot 2a \sin 2\theta + \frac{3}{8} \frac{mg}{a} (a \cot \theta - a)^2$</p> <p>$= \frac{mga}{8} [16 \sin 2\theta + 3 \cot^2 \theta - 6 \cot \theta + 3]$</p> <p>i.e. $V = \frac{mga}{8} [16 \sin 2\theta + 3 \cot^2 \theta - 6 \cot \theta] + \text{const} \quad (*)$</p>	<p>B1</p> <p>B1</p> <p>M1 A1</p> <p>M1</p> <p>M1</p> <p>A1 cso (7)</p>
(b)	<p>$\frac{dv}{d\theta} = \frac{mga}{8} [32 \cos 2\theta - 6 \cot \theta \operatorname{cosec}^2 \theta + 6 \operatorname{cosec}^2 \theta]$</p> <p>$\left. \frac{dv}{d\theta} \right _{\theta=0.535} = \frac{mga}{8} (-0.5^{0.1\dots\dots})$</p> <p>$\left. \frac{dv}{d\theta} \right _{\theta=0.545} = \frac{mga}{8} (0.2^{99\dots\dots})$</p> <p>Change of sign $\therefore \frac{dv}{d\theta} = 0$ in range, so \exists find a position of equilibrium</p>	<p>M1 A2, 1, 0</p> <p>M1</p> <p>A1</p> <p>A1 (6)</p>
(c)	<p>$\left. \frac{dv}{d\theta} \right _{0.535} < 0, \left. \frac{dv}{d\theta} \right _{\theta=0.545} > 0$</p> <p>So turning point is <i>minimum</i>, \therefore equilibrium is <i>stable</i></p>	<p>M1</p> <p>A1, A1 (3)</p> <p>(16 marks)</p>

Question Number	Scheme	Marks
<p>5. (a)</p>	<p>Auxiliary Equation.: $m^2 + 2m + 2 = 0, \Rightarrow m = -1 \pm i$ \therefore Complementary. Function is: $x = e^{-t} (A \cos t + B \sin t)$ Let $x = p \cos 2t + q \sin 2t, \dot{x} = -2p \sin 2t + 2q \cos 2t, \ddot{x} = -4x$ Sub. in D.E. $-2p \cos 2t - 2q \sin 2t - 4p \sin 2t + 4q \cos 2t = 12 \cos 2t - 6 \sin 2t$ $-2p + 4q = 12, -4p - 2q = -6$ $-10p = 0 \Rightarrow p = 0, q = 3$ $\therefore x = 3 \sin 2t + e^{-t} (A \cos t + B \sin t)$ $t = 0, x = 0 \Rightarrow 0 = A$ $\dot{x} = 6 \cos 2t - e^{-t} B \sin t + e^{-t} B \cos t$ $t = 0, \dot{x} = 0 \Rightarrow 0 = 6 + B \therefore B = -6$ $\therefore x = 3 \sin 2t - 6 e^{-t} \sin t$</p> <p>(b) $\dot{x} = 6[\cos 2t + e^{-t} \sin t - e^{-t} \cos t]$ Sub $t = \frac{\pi}{4} \dot{x} = 6[\cos 2t + e^{-t} - 6 e^{-t} \cos t]$ $\dot{x} = 6 \left[0 + e^{-\frac{\pi}{4}} \times \frac{1}{\sqrt{2}} - e^{-\frac{\pi}{4}} \times \frac{1}{\sqrt{2}} \right] = 0$ $\therefore P$ comes to instantaneous rest when $t = \frac{\pi}{4}$</p> <p>(c) sub $t = \frac{\pi}{4}$ in $x = 3 \sin \frac{\pi}{2} - 6 e^{-\frac{\pi}{4}} \frac{1}{\sqrt{2}}, = 1.07$</p> <p>(d) $t \rightarrow \infty \quad x \approx 3 \sin 2t,$ approximate period is π</p>	<p>M1, A1 M1 ft M1 M1 A1 M1 A1 B1 M1 A1 (11) M1 A1 (2) M1, A1 (2) M1, A1 (2) (17 marks)</p>

Question Number	Scheme	Marks
<p>6. (a)</p>	 <p>P before: $\rightarrow \frac{13u}{12} \cos \alpha = u$, $\uparrow \frac{13u}{12} \sin \alpha = \frac{5u}{12}$</p> <p> $\begin{matrix} \rightarrow u & \rightarrow 0 & \rightarrow v & \rightarrow \frac{3u}{5} \\ \bullet & \bullet & \bullet & \bullet \\ m & 2m & m & 2m \end{matrix}$ </p> <p>PCLM (\rightarrow) $mu = mv + 2m \frac{3u}{5}, \Rightarrow v = \frac{-u}{5}$, i.e. $\frac{u}{5} // CB$</p> <p>(b) NLI $\rightarrow eu = v_2 - v_1 \Rightarrow eu = \frac{3u}{5} - \frac{u}{5}$, i.e. $e = \frac{4}{5}$</p> <p>(c) $Q \rightarrow C$ $t_1 = \frac{d_1}{3u/5} = \frac{5d_1}{3u}$</p> <p>$P$ travels $\frac{u}{5} \times \frac{5d_1}{3u} = \frac{d_1}{3}$ in direction CB</p> <p>$\therefore P$ is $d_1 + \frac{d_1}{3} = \frac{4d_1}{3}$ from w (*)</p> <p>(d) After hitting w, Q has speed $\frac{3u}{10}$ in direction CB</p> <p>Velocity of Q relative to P in direction CB is $\frac{u}{10}$</p> <p>Time for Q to travel $\frac{4}{3}d_1$ is: $\frac{4d_1}{3} \times 10 = \frac{40d_1}{3u}$</p> <p>Total time between collisions is: $\frac{40d_1}{3u} + \frac{5d_1}{3u} = \frac{15d_1}{u}$ (*)</p> <p>(e) For collision to occur P must travel $\uparrow d_2$ and $\downarrow d_2$ in time $\frac{15d_1}{u}$</p> <p>$d_2 \uparrow$ $t_2 = \frac{d_2}{5u/12} = \frac{12d_2}{5u}$</p> <p>$\downarrow d_2$ velocity \downarrow is $\frac{5u}{24}$, $\therefore t_3 = \frac{d_2}{5u/24} = \frac{24d_2}{5u}$</p> <p>Total time is $\frac{36d_2}{5u} = \frac{15d_1}{u}$,</p> <p>$\therefore 12d_2 = 25d_1$, i.e. $d_1:d_2 = 12:25$</p>	<p>B1, B1</p> <p>M1 A1 (4)</p> <p>M1, A1 (2)</p> <p>B1</p> <p>M1</p> <p>A1 c.s.o (3)</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>A1 c.s.o (4)</p> <p>B1</p> <p>B1, B1</p> <p>M1</p> <p>A1 (5)</p> <p>(18 marks)</p>