Detailed Marking Instructions for each question

Question			Generic Scheme	Illustrative Scheme	Max Mark
1.			•[1] calculate impulse •[2] equate impulse to change in momentum •[3] calculate change in velocity and final velocity	•[1] $F \times t = -180 \times 1 \cdot 5 = -270\,\text{Ns}$ •[2] $-270 = mv - mu = m(v-u)$ •[3] $v = 12 - \frac{270}{70} = 12 - 3\frac{6}{7} = 8\frac{1}{7}\,(\text{m s}^{-1})(8 \cdot 14)$	**3**
Notes: 1. Direction of motion must be implied in either •[1] or •[2]					
Commonly Observed Responses:					
			Alternative solution		
			•[1] Use $F = ma$ to find acceleration •[2] Use equations of motion with substitution •[3] Correct value for velocity	•[1] $-180 = 70a \Rightarrow a = -\frac{18}{7}\,\text{m s}^{-2}$ •[2] $v = u + at$ with indication of direction of motion •[3] $v = 12 - \frac{18}{7}(1 \cdot 5) = 12 - 3\frac{6}{7}\,\text{m s}^{-1}$ $= 8\frac{1}{7}\,\text{ms}^{-1}\left(8 \cdot 14\text{ms}^{-1}\right)$	
Notes:					
Commonly Observed Responses:					
2.			•[1] Resolve in x direction •[2] Resolve in y direction •[3] Algebraic manipulation to find value of P •[4] Find value of Q	•[1] $P\cos 30^\circ - Q\cos 60^\circ - 80\cos 60^\circ = 0$ •[2] $Q\sin 60^\circ + P\sin 30^\circ - 80\sin 60^\circ - 64 = 0$ •[3] $P = 40\sqrt{3} + 32 \approx 101\text{N}$ •[4] $Q = 40 + 32\sqrt{3} \approx 95 \cdot 4\text{N}$	**4**
Notes:					
Commonly Observed Responses:					

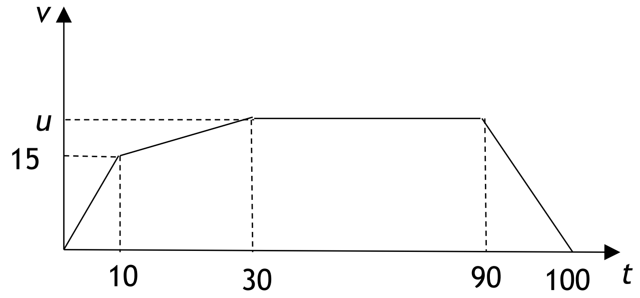
Question			Generic Scheme	Illustrative Scheme	Max Mark
3.			$\bullet^1$ calculate the displacement	$\bullet^1$ $\mathbf{d}=\begin{pmatrix}6\\4\end{pmatrix}-\begin{pmatrix}-3\\1\end{pmatrix}=\begin{pmatrix}9\\3\end{pmatrix}$	3
			$\bullet^2$ substitute into formula for work done	$\bullet^2$ work done $=\mathbf{F}\bullet\mathbf{d}$ $=\begin{pmatrix}2\\3\end{pmatrix}\bullet\begin{pmatrix}9\\3\end{pmatrix}$	
			$\bullet^3$ calculate the work done	$\bullet^3$ $=18+9$ $=27\,\mathrm{J}$	
Notes:					
Commonly Observed Responses: 1. Candidates did not know how to use scalar product and gave answer as a vector $\begin{pmatrix}18\\9\end{pmatrix}$					
4.			$y=2x-e$		3
			$\bullet^1$ Show understanding of use of product rule	$\bullet^1$ $\frac{dy}{dx}=1\left(\frac{d}{dx}\left(\frac{1}{x}\right)\right)+x\frac{d}{dx}(\ln x)$	
			$\bullet^2$ Correct differentiation	$\bullet^2$ $\frac{dy}{dx}=1+\ln x$	
			$\bullet^3$ Find equation of tangent	$\bullet^3$ when $x=e$ $y=e\ln e=e$ and $\mathrm{m}=2$ $y-e=2(x-e)$	
Notes: 1. Simplification not required for $\bullet^1$ or $\bullet^3$					
Commonly Observed Responses:					

Question			Generic Scheme	Illustrative Scheme	Max Mark
5.			•[1] Substitute values into SHM eqs $v^2 = \omega^2\left(a^2 - x^2\right)$ •[2] Obtain second equation and equate expressions for ω^2 •[3] Find value of *a* •[4] Find value of ω •[5] Calculate frequency	•[1] $4 = \omega^2\left(a^2 - 0\cdot005^2\right)$ or $1 = \omega^2\left(a^2 - 0\cdot007^2\right)$ •[2] second equation and $\omega^2 = \frac{4}{a^2 - 0\cdot005^2} = \frac{1}{a^2 - 0\cdot007^2}$ •[3] $a^2 = 5\cdot7\times10^{-5}$ $a = 7\cdot55\times10^{-3}\ \text{m}$ •[4] $\omega^2 = \frac{4}{5\cdot7\times10^{-5} - 0\cdot005^2}$ $\omega = 353\cdot6\ \text{rad s}^{-1}$ •[5] $\frac{353\cdot6}{2\pi} = 56\cdot3$ oscillations per second	5

Notes:

Commonly Observed Responses:

1. 5mm and 7mm not converted to metres

Question			Generic Scheme	Illustrative Scheme	Max Mark
6.	(a)		•[1] Correct shape of graph •[2] All annotations correct 		2
Notes:					
Commonly Observed Responses:					
	(b)	(i)	•[1] Find area under graph and equate •[2] Calculate value of u	•[1] $\frac{1}{2}(10\times15)+\frac{1}{2}(u+15)\times20$ $+60u+\frac{1}{2}(10\times u)=1725$ •[2] $u=20$	2
Notes:					
Commonly Observed Responses:					
		(ii)	•[1] One assumption stated	•[1] Path of aircraft remains in one plane (2 dimensions) Each section is in vertical plane (no wobble)	1
Notes:					
Commonly Observed Responses: 1. The assumption given had to be about *the **PATH*** of the aircraft					

<table>
<tr><th>Question</th><th>Generic Scheme</th><th>Illustrative Scheme</th><th>Max Mark</th></tr>
<tr><td>7.</td><td>•1 Find time for maximum speed

•2 Integrate to give expression of velocity with evidence of $C=0$ if indefinite integration used.

•3 Calculate velocity after 16 seconds

•4 Calculate increase in kinetic energy</td><td>•1 max speed when $a=0$
$4-\sqrt{t}=0$
$t=16\text{secs}$

•2 $v=4t-\frac{2}{3}t^{\frac{3}{2}}+C$
at $t=0, v=0 \Rightarrow C=0$,
$v=4t-\frac{2}{3}t^{\frac{3}{2}}$

•3 $v_{16}=4(16)-\frac{2}{3}(16)^{\frac{3}{2}}=\frac{64}{3}\text{ms}^{-1}$

•4 change in energy
$=\frac{1}{2}\times 9\times\left(\frac{64}{3}\right)^2-0$
$=2048\text{J}\ (2050\text{J})$</td><td>4</td></tr>
<tr><td></td><td colspan="2">Alternative solution for •3 and 4</td><td></td></tr>
<tr><td></td><td>•3 obtain an expression for the work done as an integral

•4 integrate and solve to obtain the work done</td><td>•3 $F=ma$
$F=36-9t^{\frac{1}{2}}$
$W=\int F.vdt$
$W=\int_0^{16}(36-9t^{\frac{1}{2}})(4t-\frac{2}{3}t^{\frac{3}{2}})dt$

•4 $W=\int_0^{16}(144t-60t^{\frac{3}{2}}+6t^2)dt$
$=\left[72t^2-24t^{\frac{5}{2}}+2t^3\right]_0^{16}$
$=2048\text{J}\ (2050\text{J})$</td><td></td></tr>
<tr><td colspan="4">Notes:</td></tr>
<tr><td colspan="4">Commonly Observed Responses:
1. •1 Common error $4-\sqrt{t}=0 \Rightarrow t=2$</td></tr>
</table>

Question			Generic Scheme	Illustrative Scheme	Max Mark
8.	(a)		•[1] Show equivalence of denominators	•[1] $(x+1)(x+3)(x-2)=x^3+2x^2-5x-6$	**3**
			•[2] Divide polynomials to obtain a remainder	•[2] $x^3+2x^2-5x-6\overset{\displaystyle 3}{\overline{\big)3x^3+8x^2-11}}$ with any remainder stated	
			•[3] Complete proof	•[3] $3+\dfrac{2x^2+15x+7}{x^3+2x^2-5x-6}$ **or** $3+\dfrac{2x^2+15x+7}{(x+1)(x+3)(x-2)}$	
Notes:					
Commonly Observed Responses:					
	(b)		•[1] Correct form of partial fractions	•[1] $\dfrac{A}{(x+1)}+\dfrac{B}{(x+3)}+\dfrac{C}{(x-2)}$	**4**
			•[2] Form equation	•[2] $2x^2+15x+7=A(x+3)(x-2)$ $+B(x+1)(x-2)+C(x+1)(x+3)$	
			•[3] Any two constant values	•[3] $x=-1\Rightarrow A=1$ and/or $x=-3\Rightarrow B=-2$ and/or $x=2\Rightarrow C=3$	
			•[4] Remaining value and express in correct form	•[4] $3+\dfrac{1}{x+1}-\dfrac{2}{x+3}+\dfrac{3}{x-2}$	
Notes:					
Commonly Observed Responses:					

Question			Generic Scheme	Illustrative Scheme	Max Mark
9.	(a)		•¹ Horizontal forces: $F = ma$ with substitution	•¹ $R\sin 32^{o} + 0\cdot 3R\cos 32^{o} = \dfrac{mv^2}{30}$	6
			•² Vertical forces in equilibrium with substitution	•² $R\cos 32^{o} - 0\cdot 3R\sin 32^{o} = mg$	
			•³ Algebraic manipulations	•³ $\dfrac{\sin 32° + 0\cdot 3\cos 32°}{\cos 32° - 0\cdot 3\sin 32°} = \dfrac{v^2}{30g}$	
			•⁴ Value of v	•⁴ $v = 18\cdot 3\text{ms}^{-1}$	
			•⁵ Calculate time for 1 lap	•⁵ $C = \pi d = \pi \times 60 = 188\cdot 5$ m $t = \dfrac{d}{v} = \dfrac{188\cdot 5}{18\cdot 3} = 10\cdot 3$ seconds	
			•⁶ Calculate number of laps and round down	•⁶ $300 \div 10\cdot 3 = 29\cdot 1 \Rightarrow 29$ laps	
			Alternative solution to •⁵ and •⁶		
			•⁵ Find distance travelled in 5 minutes	•⁵ $18\cdot 3 \times 300 = 5490\,\text{m}$	6
			•⁶ Calculate number of laps and round down	•⁶ $5490 \div 60\pi = 29\cdot 1 \Rightarrow 29\,\text{laps}$	

Notes:

Commonly Observed Responses:
1. Friction was ignored
2. Many candidates do not understand that motion here is horizontal and choose to treat this as motion on a slope by considering equilibrium perpendicular to the slope and then use acceleration along the slope.

Question			Generic Scheme	Illustrative Scheme	Max Mark
	(b)		•¹ Assumption stated	•¹ Track of negligible width **or** cyclist remains 30 metres from the centre of the horizontal circle.	1

Notes:

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
10.	(a)		•[1] Differentiate x and y with respect to time •[2] Find $\frac{dy}{dx}$	•[1] $\frac{dx}{dt}=4$ and $\frac{dy}{dt}=2-10t$ •[2] $\frac{dy}{dx}=\frac{2-10t}{4}\left(=\frac{1-5t}{2}\right)$	**2**
Notes:					
Commonly Observed Responses:					
	(b)	(i)	•[1] Substitute $t=0$ to give the initial velocities horizontally and vertically •[2] Find angle	•[1] $t=0: \frac{dy}{dx}=\frac{2}{4}=0\cdot5$ •[2] $\tan^{-1}(0\cdot5)=26\cdot6^{0}$ or $0\cdot464$	**2**
Notes:					
Commonly Observed Responses:					
		(ii)	•[1] Condition for angle of 45^{0} below horizontal •[2] Solve for time	•[1] $\frac{dy}{dx}=-1$ •[2] $t=\frac{6}{10}=0\cdot6$ seconds	**2**
Notes					
Commonly Observed Responses: **1.** In b(ii) $\frac{dy}{dx}=1$ gives an answer of $t=-0\cdot2$ seconds which cannot be explained.					

<table>
<tr><th colspan="3">Question</th><th>Generic Scheme</th><th>Illustrative Scheme</th><th>Max Mark</th></tr>
<tr><td>11.</td><td></td><td></td><td>•¹ Find the area under the curve

•² State the correct integral for $A\bar{x}$ with substitution

•³ State the correct integral for $A\bar{y}$ with substitution

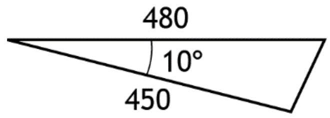
•⁴ Find the centre of mass</td><td>•¹ Shaded area = $\int_0^4 x^3 dx = 64$ sq units

•² $A\bar{x} = \int_0^4 xy dx = \int_0^4 x^4 dx = 204\cdot8$
$\bar{x} = \frac{204\cdot8}{64} = 3\cdot2$

•³ $A\bar{y} = \int_0^4 \frac{1}{2}y^2 dx = \int_0^4 \frac{x^6}{2} dx = 1170\cdot3$
$\bar{y} = \frac{1170\cdot3}{64} = 18\cdot3$

•⁴ Centre of Mass: $(3\cdot2, 18\cdot3)\left[\frac{16}{5}, \frac{128}{7}\right]$</td><td>4</td></tr>
<tr><td colspan="6">Notes:</td></tr>
<tr><td colspan="6">Commonly Observed Responses:
1. Formula for $A\bar{y}$ not known.</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Alternative solution for •³ and •⁴</td><td></td></tr>
<tr><td></td><td></td><td></td><td>•3 Use method as $A\bar{x}$ but Replacing x and y

•4 Find the centre of mass</td><td>$A\bar{y} = \int_0^{64} y(4-x)dy = \int_0^{64} y(4-y)^{\frac{1}{3}}dy$
$= \int_0^{64} (4y - y^{\frac{4}{3}})dy = \frac{8192}{7} \Rightarrow \bar{y} = \frac{128}{7}$</td><td></td></tr>
</table>

Question			Generic Scheme	Illustrative Scheme	Max Mark
12.	(a)		•[1] Create speed/distance triangle and annotate	•[1] true speed = $\frac{1080}{2\cdot 25}=480$  $\lvert\mathbf{v}_w\rvert^2 = 480^2+450^2-2\times480\times450\times\cos10°$	**3**
			•[2] Calculate wind speed	•[2] $86\cdot 4$ km h^{-1}	
			•[3] Calculate direction	•[3] $\cos^{-1}\left(\frac{86\cdot4^2+450^2-480^2}{2\times86\cdot4\times450}\right)=105\cdot2°$ So bearing is $025\cdot2°$	

Notes:
1. Accept $025°$ or $205\cdot2°$
2. Any **angle** must include reference to a compass direction (from S25·2°W)

Commonly Observed Responses:
1. ***Direction*** of wind needed to be referenced.

	(b)	(i)	•[1] State valid reason	•[1] wind now acting against direction of travel	**1**

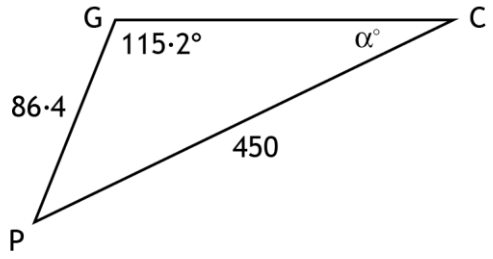
Notes:

Commonly Observed Responses:

<table>
<tr><th colspan="3">Question</th><th>Generic Scheme</th><th>Illustrative Scheme</th><th>Max Mark</th></tr>
<tr><td></td><td></td><td>(ii)</td><td>•¹ Redraw diagram (could be implied by mark 2)

•² Calculate an angle and substitute

•³ Calculate true speed

•⁴ Calculate difference in travel time</td><td>•¹

•² $\frac{\sin 115\cdot 2}{450}=\frac{\sin C}{86\cdot 4}\Rightarrow C=10\cdot 0°$

$P=54\cdot 8^{\circ}$

•³
$v^2=450^2+86\cdot 4^2-2\times 450\times 86\cdot 4\times \cos 54\cdot 8°$
true speed = $406\cdot 38$ km h^{-1}

•⁴
$t=\frac{1080}{406\cdot 38}=2\cdot 66$ hours = 2 hours 40 mins

25 mins longer</td><td>4</td></tr>
<tr><td colspan="6">Notes:
1. •⁴ Markers must work with candidate's appropriate rounding.</td></tr>
<tr><td colspan="6">Commonly Observed Responses:</td></tr>
</table>

Question			Generic Scheme	Illustrative Scheme	Max Mark
Alternative solution by VECTORS					
12.	(a)		• [1] Create vector equation and use to find wind vector	•[1] $2\frac{1}{4}\begin{pmatrix}450\cos 10°\\-450\sin 10°\end{pmatrix}+2\frac{1}{4}\mathbf{v}_{\mathrm{w}}=\begin{pmatrix}1080\\0\end{pmatrix}$ $\mathbf{v}_{\mathrm{w}}=\begin{pmatrix}36\cdot 84\\78\cdot 14\end{pmatrix}$	**3**
			• [2] Calculate wind speed	•[2] $\lvert\mathbf{v}_{\mathrm{w}}\rvert=86\cdot 4\,\mathrm{km\,h^{-1}}$	
			• [3]Calculate direction	•[3] $\tan^{-1}(\frac{78\cdot 14}{36\cdot 84})=64\cdot 8°$ So wind bearing is 025·2°	

Notes:

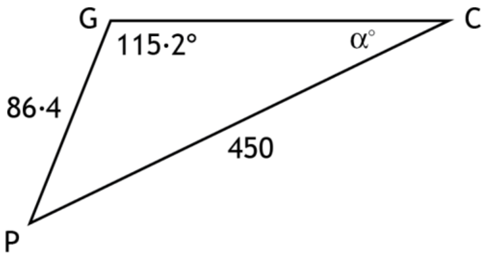
1. Accept 025°
2. Any angle must include reference to a compass direction (from S19°W)

Commonly Observed Responses:

	(b)	(i)	• [1] State valid reason	• [1] wind now acting against direction of travel	**1**

Notes:

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
		(ii)	•[1] Redraw diagram (could be implied by mark 2)	•[1] 	4
			•[2] vector equation to find α°	•[2] $\begin{pmatrix} -450\cos\alpha \\ -450\sin\alpha \end{pmatrix} + \begin{pmatrix} 86\cdot4\sin 25\cdot2° \\ 86\cdot4\cos 25\cdot2° \end{pmatrix} = \begin{pmatrix} -v \\ 0 \end{pmatrix}$ $\alpha = 10\cdot0°$	
			•[3] Substitute in vector equation to find time of flight	•[3] $t\begin{pmatrix} -450\cos10° \\ -450\sin10° \end{pmatrix} + t\begin{pmatrix} 86\cdot4\sin 25\cdot2° \\ 86\cdot4\cos 25\cdot2° \end{pmatrix} = \begin{pmatrix} -1080 \\ 0 \end{pmatrix}$ $t = 2\cdot66$ hours = 2hr 40 mins	
			•[4] Calculate difference in travel time	•[4] Difference in time of flight 25 minutes	

Notes:

1. Markers must work with candidate's appropriate rounding.

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
13.	(a)		•¹ state integral to be used to find the volume with substitution	•¹ $V=\int \pi y^2 dx$ $V=\int \pi e^{\frac{x}{6}} dx$	**3**
			•² integrate and state limits	•² $V=\int_{15}^{30} \pi e^{\frac{x}{6}} dx$ $=\left[6\pi e^{\frac{x}{6}}\right]_{15}^{30}$	
			•³ substitute in limits and calculate the volume	•³ $V=6\pi e^{5}-6\pi e^{2\cdot 5}$ (2570cm^3)	
Notes: 1. •³ Accept any numeric answer correct to at least 3 significant figures (2570cm^3)					
Commonly Observed Responses:					
	(b)		•⁴ state volume equated to half original volume	•⁴ $6\pi e^{\frac{a}{6}}-6\pi e^{2\cdot 5}=1285$	**3**
			•⁵ solve equation	•⁵ $e^{\frac{a}{6}}=80\cdot 3$ $a=26\cdot 3$	
			•⁶ interpret required solution	•⁶ $26\cdot 3-15=11\cdot 3\text{cm}$ Hence line should be positioned $10\cdot 1\text{cm}$ up the side of the bowl.	
Notes:					
Commonly Observed Responses:					

Question			Generic Scheme	Illustrative Scheme	Max Mark
14.			•¹ Consider force P parallel to the plane	•¹ $P = W\sin\theta - \mu R_1$	**7**
			•² Equilibrium perp to slope and substitution	•² $R_1 = W\cos\theta$ $P = W\sin\theta - \mu\left(W\cos\theta\right)$	
			•³ Consider horizontal force Q along and perp to plane and equation for equilibrium.	•³ $Q\cos\theta + \mu R_2 = W\sin\theta$ $R_2 = W\cos\theta + Q\sin\theta$ $Q\cos\theta = W\sin\theta - \mu\left(W\cos\theta + Q\sin\theta\right)$	
			•⁴ Rearrange for μ	•⁴ $\mu = \dfrac{W\sin\theta - Q\cos\theta}{\mathrm{W}\cos\theta + Q\sin\theta}$ or $\mu = \dfrac{W\sin\theta - P}{W\cos\theta}$	
			•⁵ Equate expressions	•⁵ $\dfrac{W\sin\theta - Q\cos\theta}{\mathrm{W}\cos\theta + Q\sin\theta} = \dfrac{W\sin\theta - P}{W\cos\theta}$	
			•⁶ Simplify algebra	•⁶ $W^2\sin\theta\cos\theta - QW\cos^2\theta =$ $W^2\sin\theta\cos\theta - PW\cos\theta + QW\sin^2\theta - PQ\sin\theta$	
			•⁷ Use $\cos^2\theta + \sin^2\theta = 1$ to complete proof	•⁷ $\mathrm{P}(\mathrm{W}\cos\theta + Q\sin\theta) =$ $QW(\sin^2\theta + \cos^2\theta)$ $P = \dfrac{QW}{Q\sin\theta + \mathrm{W}\cos\theta}$	

Notes:

1. If candidates have block slipping up the slope, they cannot gain •¹ but all other marks are available

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
15.	(a)		•¹ Establish forces involved	•¹ $ma = -6v - \frac{\lambda}{l}x$ or $-6v - 20x$	**2**
			•² substitute values and re-arrange	•² $0 \cdot 25\frac{d^2x}{dt^2} = -6\frac{dx}{dt} - 20x$ $\frac{d^2x}{dt^2} + 24\frac{dx}{dt} + 80x = 0$	

Notes:

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
	(b)		•¹ set up auxiliary equation	•¹ $m^2 + 24m + 80 = 0$	**6**
			•² solve quadratic equation	•² $(m+20)(m+4) = 0 \Rightarrow m = -4$ or $m = -20$	
			•³ general solution	•³ $x = Ae^{-4t} + Be^{-20t}$	
			•⁴ initial condition $x = 0 \cdot 2$ when $t = 0$	•⁴ $0 \cdot 2 = Ae^0 + Be^0 \Rightarrow A + B = 0 \cdot 2$	
			•⁵ differentiate to use initial condition for velocity	•⁵ $\frac{dx}{dt} = -4Ae^{-4t} - 20Be^{-20t} \Rightarrow -4A - 20B = 0$	
			•⁶ solve for *A* and *B*, particular solution	•⁶ $A = 0 \cdot 25,\ B = -0 \cdot 05$ $x = 0 \cdot 25e^{-4t} - 0 \cdot 05e^{-20t}$	

Notes:

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
	(c)		•¹ differentiate to obtain an expression for acceleration •² solve for t •³ substitute for t to give displacement, x	•¹ $\ddot{x} = 4e^{-4t} - 20e^{-20t} = 0$ •² $e^{-4t} = 5e^{-20t}$ $-4t = \ln 5 - 20t$ $t = \frac{1}{16}\ln 5$ •³ $x = \frac{1}{4}e^{-0\cdot25\ln 5} - \frac{1}{20}e^{-1\cdot25\ln 5} = 0\cdot160\,\text{m}$	3
Notes:					
Commonly Observed Responses:					
16.	(a)		•¹ state the horizontal and vertical equations of motion •² rearrange for t and start substitution •³ obtain required equation	•¹ $x = Vt\cos\theta \quad y = Vt\sin\theta - \frac{1}{2}gt^2$ •² $t = \frac{x}{V\cos\theta}$ $y = \left(V\sin\theta \times \frac{x}{V\cos\theta}\right) - \frac{1}{2}g\left(\frac{x}{V\cos\theta}\right)^2$ •³ $y = x\tan\theta - \frac{gx^2}{2V^2\cos^2\theta}$ $y = x\tan\theta - \frac{gx^2}{2V^2}\left(1 + \tan^2\theta\right)$	3
Notes: 1. **•¹ can be implied by •² and •² can be implied by •³**					
Commonly Observed Responses:					

Question			Generic Scheme	Illustrative Scheme	Max Mark
Alternative solution for •[1] using calculus					
			• [1] state horizontal and vertical equations of motion using calculus	$\frac{d^2x}{dt^2}=0$ $\frac{dx}{dt}=c$ when $t=0$ $\frac{dx}{dt}=V\cos\theta$ $c=V\cos\theta$ $\text{x}=\int(v\cos\theta)\,dt=(V\cos\theta)t+c_2$ when $t=0$ $x=0$ $c_2=0$ $x=(V\cos\theta)t$ $\frac{d^2y}{dt^2}=-g$ $\frac{dx}{dt}=\int(V\sin\theta)\,dt=-gt+c_3$ when $t=0\,\frac{dy}{dt}=V\sin\theta c_3=V\sin\theta$ $y=\int(V\sin\theta-gt)\,dt$ $y=(V\sin\theta)t-\frac{1}{2}gt^2+c_4$ when $t=0$ $y=0$ $c_4=0$ $y=(V\sin\theta)t-\frac{1}{2}gt^2$	**3**
Alternative solution for •[1] using equations of motion					
			• [1] state horizontal and vertical equations of motion using equations of motion	$x=V\cos\theta\times t$ $s=ut+\frac{1}{2}at^2$ $y=(V\sin\theta)t-\frac{1}{2}gt^2$	**3**

Question			Generic Scheme	Illustrative Scheme	Max Mark
	(b)		•4 Use equation from part (a) to obtain two equations for h •5 equate expressions and some algebraic manipulation •6 Eliminate V •7 simplify and eliminate h •8 find angle of projection	•4 $h = 4h\tan\theta - \frac{16h^2 g}{2V^2}\left(1+\tan^2\theta\right)$ $h = 5h\tan\theta - \frac{25h^2 g}{2V^2}\left(1+\tan^2\theta\right)$ •5 $\frac{h^2 g}{V^2}\left(1+\tan^2\theta\right) = \frac{2}{25}\left(5h\tan\theta - h\right)$ $\frac{h^2 g}{V^2}\left(1+\tan^2\theta\right) = \frac{1}{8}\left(4h\tan\theta - h\right)$ •6 $\frac{2}{25}(5h\tan\theta - h) = \frac{1}{8}(4h\tan\theta - h)$ •7 $80h\tan\theta - 16h = 100h\tan\theta - 25h$ $20\tan\theta = 9$ •8 $\tan\theta = \frac{9}{20} \Rightarrow \theta = 24\cdot2°\ (0\cdot423)$	5

Notes:

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
	(b)		**Alternative solution**		
			•[4] Express as a quadratic and obtain equation.	•[4] quadratic passes through the origin so is of the form $y = ax^2 + bx$ Passes through the points $(4h, h)$ and $(5h, h)$ $h = 16h^2a + 4hb$ $h = 25h^2a + 5hb$	
			•[5] solve simultaneous equations to obtain expressions for a and b	•[5] $5h = 80h^2a + 20hb$ $4h = 100h^2a + 20hb$ $a = \frac{-1}{20h}$ and $b = \frac{9}{20}$	
			•[6] state equation of the trajectory	•[6] $y = \frac{-1}{20h}x^2 + \frac{9}{20}x$	
			•[7] determine gradient when $x = 0$	•[7] $\frac{dy}{dx} = \frac{-1}{10h}x + \frac{9}{20}$ at $x = 0$ $\frac{dy}{dx} = \frac{9}{20}$	
			•[8] solve to find angle of projection	•[8] $m = \tan\theta \Rightarrow \tan\theta = \frac{9}{20}$ $\theta = 24\cdot 2^{\circ}$	

Notes:

Commonly Observed Responses:

Question			Generic Scheme	Illustrative Scheme	Max Mark
17.	(a)	(i)	•[1] Consider energy at two positions	•[1] at starting position $E_k = \frac{1}{2}mu^2$ Elsewhere $E_k + E_p = \frac{1}{2}mv^2 + mg\left(r - r\cos\theta\right)$	**4**
			•[2] Use conservation of energy	•[2] $\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mg\left(r - r\cos\theta\right)$	
			•[3] Find expression for velocity	•[3] $v^2 = u^2 - 2rg\left(1 - \cos\theta\right)$	
		(ii)	•[4] $F = ma$ radially and show expression for tension	•[4] $T - mg\cos\theta = \frac{mv^2}{r}$ and complete	**2**
			•[5] Interpret condition for full circles	•[5] $T > 0$ when $\theta = 180°$ and substitute	
			•[6] Find expression for u	•[6] $u > \sqrt{5rg}$	
Notes: 1. accept $T \geq 0$ and $u \geq \sqrt{5rg}$					
Commonly Observed Responses: Condition for complete circle given as $v > 0$					
	(b)		•[7] Interpret condition for string going slack and substitute	•[7] $T = 0$ and substitute	**3**
			•[8] Find angle	•[8] $\cos\theta = -\frac{2}{3}$	
			•[9] Find height	•[9] $h = r - r\cos\theta = \frac{5}{3}r$ $h = r - r\cos\theta = \frac{5}{3}r$	

[END OF MARKING INSTRUCTIONS]