Question	Scheme	Marks	AOs
5(a)	$4m^2+4m+37=0 \Rightarrow m=-\frac{1}{2}\pm 3\text{i}$	M1	1.1b
	$h=\text{e}^{-0.5t}\left(A\cos 3t+B\sin 3t\right)$	A1	1.1b
		(2)	
(b)	$t=0,\ h=-20 \Rightarrow A=-20$	M1	3.4
	$\frac{\text{d}h}{\text{d}t}=-0.5\text{e}^{-0.5t}\left(A\cos 3t+B\sin 3t\right)+\text{e}^{-0.5t}\left(-3A\sin 3t+3B\cos 3t\right)$ $t=0,\ \frac{\text{d}h}{\text{d}t}=55 \Rightarrow B=\ldots$ (NB $B=15$)	M1	3.4
	$(h=)\text{e}^{-0.5t}\left(15\sin 3t-20\cos 3t\right)$	A1	1.1b
	$-0.5\text{e}^{-0.5t}\left(15\sin 3t-20\cos 3t\right)+\text{e}^{-0.5t}\left(60\sin 3t+45\cos 3t\right)=0$ or e.g. $-0.5\text{e}^{-0.5t}\left(15\sin 3t-20\cos 3t\right)+\frac{25\sqrt{37}}{2}\text{e}^{-0.5t}\sin\left(3t+\arctan\frac{22}{21}\right)=0$ $\Rightarrow t=\ldots$	M1	3.1b
	$\tan 3t=-\frac{22}{21}$ or e.g. $3t+\tan^{-1}\frac{22}{21}=0$	A1 **M1 on ePEN**	2.1
	$t=0.778$ s	A1	1.1b
	$h=\text{e}^{-0.5\times\text{"0.778"}}\left(15\sin\left(3\times\text{"0.778"}\right)-20\cos\left(3\times\text{"0.778"}\right)\right)$	**d**M1	1.1b
	= 16.7 cm	A1	3.2a
		(8)	
(c)	E.g. considers large values of t in the model for h **or** states that for large values of t, h becomes smaller or becomes zero	M1	3.4
	E.g. • The value of h is very small when t is large and this is likely to be correct (as the displacement of end of the board should get smaller and smaller) • This suggests the model is suitable • This is realistic • This is suitable as the board will tend towards its equilibrium position • When t is large the value of h is never zero so the model is not really appropriate for large values of t	A1 **B1 on ePEN**	3.2b
		(2)	
			(12 marks)

Notes

(a)

M1: Uses the model to form and solve the auxiliary equation $4m^2+4m+37=0$

See General Guidance for awarding this mark. This can be implied by correct values for m (from calculator)

A1: Correct general solution including "$h=$"

(b)

M1: Uses the model and the initial conditions to establish the value of "A". Need to see $t = 0$ and $h = \pm 20$ leading to a value for "A". This may be implied by $A = -20$ or $A = 20$.
M1: Differentiates their model using the product rule and uses the initial conditions, $t = 0$ with $\mathrm{d}h/\mathrm{d}t = \pm 55$, to establish the value of "B"
A1: Correct particular solution or correct values for A and B
M1: Uses their solution to the model with a correct strategy to obtain a value for t e.g. differentiates or uses their derivative from earlier, sets equal to zero and solves for t
A1(M1 on ePEN): Correct equation for t
A1: Correct value for t (allow awrt 0.778 if necessary) but this value may be implied.
dM1: Uses the model and their **positive** value for t to find the maximum displacement - **if their t is incorrect there must be some indication that they are using their h and not just a number written down. E.g. must see substitution into their h or they re-state their h and obtain a value for h.**
Dependent on all the previous method marks
A1: Correct value (awrt 16.7 (units not needed))
(c)
M1: Considers the model for large values of t either by substituting values or by considering the expression and commenting on its behaviour for large values of t. E.g. as $t \to \infty$, $h \to 0$ or as $t \to \infty$, $e^{-0.5t} \to 0$ or as $t \to \infty$ the oscillations become smaller etc.
A1: Makes a suitable comment – see scheme for examples