| Question Number | Answer | Mark | Additional Guidance |
|---|---|---|---|
| 5a | Use of $EPE = \dfrac{\lambda x^2}{2a}$ | B1 | Correct form seen at least once |
| | Energy equation | M1 | Dimensionally correct. Need all 3 terms |
| | $\dfrac{\lambda \times (2a)^2}{2a} = mg \times \dfrac{5}{2}a + \dfrac{\lambda\left(\frac{a}{2}\right)^2}{2a}$ | A1 | Correct unsimplified equation |
| | $\dfrac{15\lambda a}{8} = \dfrac{5mga}{2} \quad \Rightarrow \lambda = \dfrac{4}{3}mg$ * | A1* | Obtain **given answer** from full and correct working. Must see at least one line of working e.g. combining epe terms. |
| | | (4) | |
| | | | |
| 5b | Conservation of energy | M1 | Dimensionally correct. Need all 3 terms |
| | $\dfrac{1}{2}mv^2 + mg \times 2a = \dfrac{4}{3}mg \times \dfrac{(2a)^2}{2a}$ | A1<br>A1 | Unsimplified equation with at most one error<br>Correct unsimplified equation |
| | $\Rightarrow v = \sqrt{\dfrac{4ag}{3}}$ | A1 | Any equivalent form<br>Eg. $\dfrac{2\sqrt{3ag}}{3}$<br>Accept $1.2\sqrt{ag}$ or better |
| | | (4) | |
| | | | |
| 5c | At max speed $T = mg$ | M1 | Form equation for equilibrium |
| | $\Rightarrow mg = \dfrac{4mg}{3} \times \dfrac{x}{a}$ | A1 | Correct unsimplified equation |
| | $\Rightarrow x = \dfrac{3}{4}a, \quad AE = x + a = \dfrac{7}{4}a$ * | A1* | Obtain **given answer** from full and correct working with no errors. Allow without "$AE =$" |
| | | (3) | |
| 5c Alt1 | Form equation using energy when extension is $x$ and maximise $v$. | | Forms equation for energy at an arbitrary point **and** then tries to find the value of their $x$ which maximise $v$ or $v^2$ (e.g. completing the square or differentiating). Note their "$x$" could be any |

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|---|---|---|---|
| | | | consistently used position e.g. *AP* or *DP*. |
| | $\frac{4mg(2a)^2}{3\times 2a}=\frac{4mg(x)^2}{3\times 2a}+mg(2a-x)+\frac{1}{2}mv^2$<br>$v^2=-\frac{4g}{3a}x^2+2gx+\frac{4}{3}ag$ | | Correct unsimplified equation |
| | $v_{\max}$ when $x=\frac{3}{4}a\Rightarrow AE=\frac{7}{4}a$ * | | Obtain **given answer** from full and correct working with no errors. Allow without "*AE* =" |
| | | | |
| 5c<br>Alt2 | Max speed at equilibrium position and as this is a spring that position is halfway between the positions where $v = 0$ | M1 | Observes that max speed occurs at equilibrium position and justifies use of midpoint by stating either:<br>- it is a spring / never slack **or**<br>- *P* moves with SHM **and** attempts to find midpoint |
| | $AE=\frac{\frac{1}{2}a+3a}{2}$ | A1 | Correct unsimplified equation |
| | $AE=\frac{7}{4}a$ * | A1* | Obtain **given answer** from full and correct working with no errors. Allow without "*AE* =" |
| | | (3) | |
| | | | |
| 5d | Equation of motion | M1 | Must be using distance from *E* |
| | $m\ddot{y}=mg-\frac{\frac{4mg}{3}\left(y+\frac{3}{4}a\right)}{a}$ | A1 | Correct unsimplified equation using distance from *E* (condone if using *x* again; allow "*a*" etc. for acceleration for this mark). |
| | $\Rightarrow m\ddot{y}=-\frac{4mg}{3a}y,\quad \ddot{y}=-\frac{4g}{3a}y$<br>Of the form $\ddot{y}=-\omega^2 y$ so SHM * | A1* | Obtain **given answer** from full and correct working. Requires a conclusion mentioning "SHM" and acceleration must be second derivative of displacement from *E* wrt *t*. |
| | | (3) | |
| | | **(14)** | |