M1. A

[1]

M2. D

[1]

M3. C

[1]

M4. B

[1]

M5 C

[1]

M6. A

[1]

M7. C

[1]

M8. C

[1]

M9. C

[1]

M10. D

[1]

M11. B

[1]

M12. C

[1]

M13. B

[1]

M14. C

[1]

M15. C

[1]

M16. A

[1]

M17. (a) (i) $mg = ke$ **(1)**

$k =$ [redacted] $= 61(.3)$ N m^{-1} **(1)**

(ii) $T = \left(= 2\pi\sqrt{\frac{m}{k}} \right) = 2\pi\sqrt{\frac{0.69}{61.3}}$ **(1)** (= 0.667 s)

$f\left(= \frac{1}{T} \right) = \frac{1}{0.667}$ **(1)** (= 1.5(0) Hz)

4

(b) The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of QWC but the candidates' QWC in this answer will be one of the criteria used to assign a level and award the marks for this part of the question.

Level	**Descriptor** an answer will be expected to meet most of the criteria in the level descriptor	**Mark range**
Good **3**	– answer supported by appropriate range of relevant points – good use of information or ideas about physics, going beyond those given in the question – argument well structured with minimal repetition or irrelevant points – accurate and clear expression of ideas with only minor errors of spelling, punctuation and grammar	**5-6**
Modest **2**	– answer partially supported by relevant points – good use of information or ideas about physics given in the question but limited beyond this – the argument shows some attempt at structure – the ideas are expressed with reasonable clarity but with a few errors of spelling, punctuation and grammar	**3-4**
Limited **1**	– valid points but not clearly linked to an argument structure – limited use of information or ideas about physics – unstructured – errors in spelling, punctuation and grammar or lack of fluency	**1-2**
0	– incorrect, inappropriate or no response	**0**

examples of the sort of information or idea that might be used to support an argument

- forced vibrations (at 0.2 Hz) **(1)**
- amplitude fairly large (≈ 30 mm) **(1)**
- in phase with driver **(1)**
- resonance (at 1.5 Hz) **(1)**
- amplitude very large (> 30 mm) **(1)**
- oscillations may appear violent **(1)**
- phase difference at 90º **(1)**
- forced vibrations (at 10 Hz) **(1)**
- small amplitude **(1)**
- out of phase with driver or phase lag of π on driver **(1)**

[10]

M18. (a) (i) speed at P, v ($= \sqrt{2gh}$) = $\sqrt{2 \times 9.81 \times 25}$ ✓

= 22(.1) (m s^{-1}) ✓

2

(ii) use of $F = k\Delta L$ gives $d \left(= \frac{F}{K} \right) = \frac{58 \times 9.81}{54}$ ✓

= 11 (10.5) (m) ✓

2

(b) (i) period $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{58}{54}}$ ✓ (= 6.51 s)

time for one half oscillation = 3.3 (3.26) (s) ✓

2

(ii) frequency $f\left(=\frac{1}{T}\right)=\frac{1}{6.51}$ ✓ (= 0.154 (Hz))

use of $v = \pm 2\pi f\sqrt{A^2 - x^2}$ when x = 10.5 m and v = 22.1 m s^{-1} gives 22.1^2

$= 4\pi^2 \times > 0.154^2 (A^2 - 10.5^2)$ ✓

from which A = 25.1 (m) ✓

[alternatively, using energy approach gives $\frac{1}{2} mv_P^2 + mg\Delta L = \frac{1}{2} k(\Delta L)^2$ ✓

$\therefore (29 \times 22.1^2) + (58 \times 9.81 \times \Delta L) = 27 (\Delta L)^2$

solution of this quadratic equation gives ΔL = 35.7 (m) ✓

from which A = 25.2 (m) ✓]

3

(c) bungee cord becomes slack ✓

student's motion is under gravity (until she returns to **P**) ✓

has constant downwards acceleration **or** acceleration is not $\propto$ displacement ✓

2

(d) (i) when student is at **R** or at bottom of oscillation ✓

1

(ii) at uppermost point **or** where it is attached to the railing ✓

because stress = F/A and force at this point includes weight of whole cord ✓

[accept alternative answers referring to mid-point of cord because cord will show thinning there as it stretches **or** near knots at top or bottom of cord where A will be smaller with a reference to stress = F/A]

2

[14]