

Name of the Student: _____

Max. Marks : 20 Marks

Time : 20 Minutes

Mark Schemes

Q1.

- (a) annotates **Figure 1** to identify equilibrium position; some (or all) of the mark should be below the bob

or

(bottom of mark) should be level with bottom of bob 1✓

this is where (the pendulum / bob) is moving fastest / (pendulum has) maximum kinetic energy

or

this is where the transit time is least 2✓

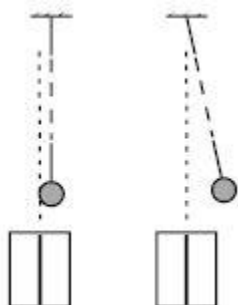
for 1✓ condone a poorly-annotated sketch if intention is clarified in 2

✓; do not allow talkout

do not insist on seeing the outline of the card as long as the vertical line is seen;

condone arrows $\uparrow \downarrow$ etc; blobs $\bullet + \times$ are neutral

allow vertical line of the mark to be aligned with either edge of the bob in the left-hand view or marked directly below point of suspension (within one-quarter of bob radius) in the right-hand view, eg



if marks are shown on each view of the pendulum, then each separately must satisfy the criteria for 1✓

2✓ is contingent on award of 1✓

for 2✓ comments about why the mark is not aligned with bob in right-hand view are neutral (at equilibrium) 'acceleration is zero' is neutral

2

- (b) use of appropriate horizontal scale or wtte 1✓

use of set-square with edge made vertical or other suitable equipment to eliminate parallax error in A_R 2✓

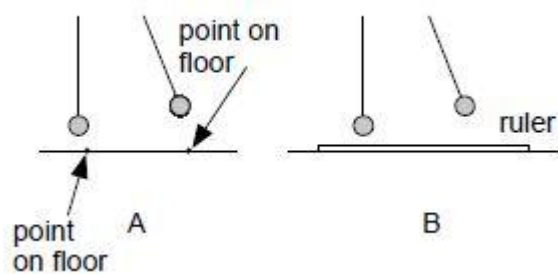
measures A_R from (either) edge of displaced bob 3✓

any of 1✓ 2✓ or 3✓ can be earned by suitable annotation to

Figure 2

for 1✓ ruler or 'mm scale' only;

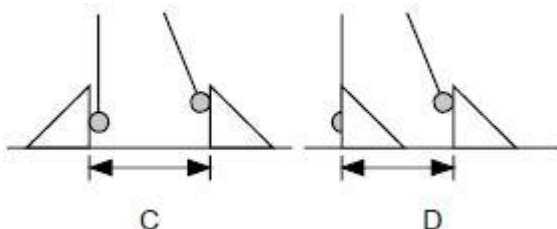
'measuring with a ruler between points marked on the floor' is acceptable (see A below) or use of a 'ruler placed on floor' (see B)



for 2✓ allow use of plumb line, spirit level, video or photographic equipment; reject clamp stand

any use of the fiducial mark or the idea that the supporting beam is horizontal are neutral

withhold 3✓ unless candidates explains that allowance is being made for radius / diameter of bob (see C and D below)



MAX 2

- (c) extrapolation of curve to (at least) $x = 0.70$ m 1✓

for 1✓ extrapolation must be continuous and smooth; allow (ruled) straight line;

reject hairy, thick or dashed lines

1

consistently-recorded min 3 dp values for $T_{0.35}$ and $T_{0.70}$ 2✓

for 2✓ allow values seen in working;

$T_{0.35}$ must round to 2.322; condone $T_{0.70}$ by eye

evidence of valid calculation (check denominator correct);

percentage increase in range 1.4(0) % to 1.8(0) % 3✓

don't insist on horizontal or vertical lines between curve and vertical axis on **Figure 3**

for 3✓ expected answer is 1.51%

2

- (d) rejects anomalous 0.247;

average $A_5 \geq 3$ sf (that rounds to) 0.221 (s) 1✓

correct uncertainty calculation or 0.004(0) (s) seen 2✓

or

does not reject 0.247;

average $A_5 =$ (rounds to) 0.226 (s);

correct uncertainty calculation or 0.015 (s) seen 12✓

correct % uncertainty from $\frac{\text{their half range}}{\text{their average}} \times 100 \geq 2 \text{ sf}$ 3✓

0.221 and 1.8 % on answer lines earn 123✓✓✓

1✓ (0.247 rejected) full answer 0.2214 (s)

2✓ from half range; can be inferred from working

3✓ if 12✓✓ full answer 1.81 %; allow 1.8 % or 1 sf 2 %
when 0.247 is not rejected

12✓ full answer 0.2257 (s)

3✓ full answer 6.647 %; allow 6.64 / 6.65 % or 2 sf 6.6 / 6.7 %
for 3✓ allow ECF only if uncertainty is from half range

3

(e) $\ln(A_4 / m) = -1.492$ ✓

CAO 3 dp only

1

(f) vertical scale with one major (cm) grid square = 0.02 **or** 0.025;

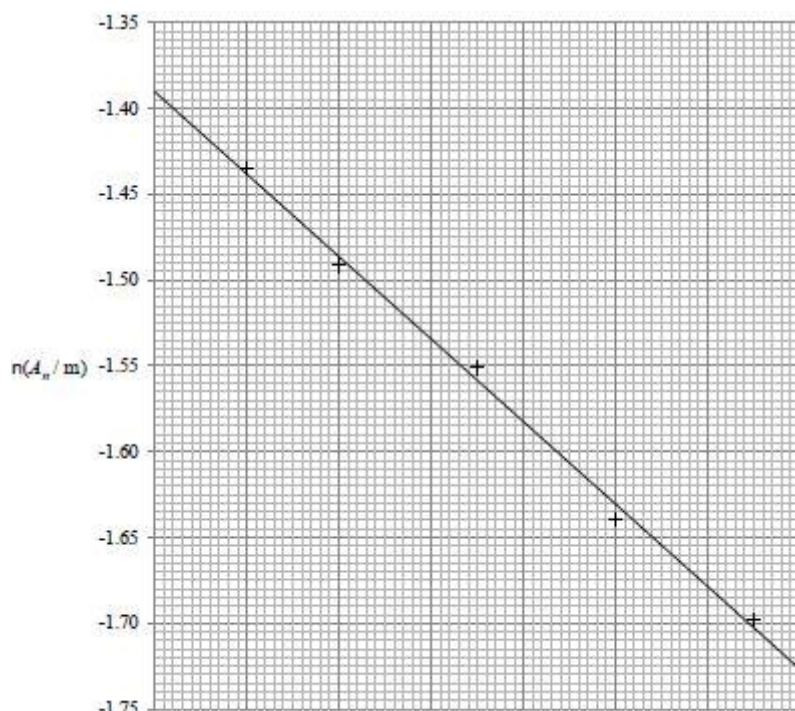
maximum spacing of values marked on the scale = 5 cm 1✓

points plotted for $n = 2, 4, 7, 10$ and 13;

suitable continuous ruled line of negative gradient from $n = 2$ to (at least) $n = 13$;

line must pass above $n = 4$ **and** $n = 10$ points

and must pass below $n = 7$ point 2✓



withhold both marks for false plot

for 1 ✓ scale might go (down page) from -1.40 to -1.72 (1 square = 0.02) or from -1.30 to -1.70 (1 square = 0.025);

scale must cover range of plotted points; do not insist on use of broken scale convention

no credit for reversed values leading to graph with 'positive' gradient;

no credit for missing / inconsistent minus signs or for inconsistent dp in labelled values

for 2 ✓ allow ECF acceptable line based on accurate plot of incorrect n = 4 point

allow ECF for graph with 'positive' gradient due to reversed scale, eg line must pass **below** $n = 4$ **and** $n = 10$ points **and** must pass **above** $n = 7$ point

accept only 4 points if $n = 4$ is not tabulated; line must pass **between** $n = 7$ and $n = 10$

ignore any plot of $\ln(A_5 / m)$ based on part (d) data;

withhold mark for poor points eg blobs or for thick / faint / non-continuous line

2

(g) (any) correct expression with $\ln A_n$ as subject 1 ✓

$$\delta = e^{-\text{gradient}} \text{ or } \text{wtte } 2 \checkmark$$

for 1 ✓ $y = mx + c$ idea is required

either $\ln A_n = -n \ln \delta + \ln A_0$ ($y = mx + c$)

or $\ln A_n = \ln A_0 - n \ln \delta$ ($y = c + mx$)

not $\ln A_n = \ln A_0 - \ln \delta^n$

treat 'lg A' as a slip

allow use of 'log A' for 1 ✓ but no ECF in 2 ✓

for 2 ✓

δ must be the subject, reject $\ln \delta = -\text{gradient}$ etc

allow ECF if 1 ✓ is withheld for missing – sign;
 if gradient is evaluated accept $\delta = e^{(+)0.024}$ or $\delta = 1.02(4)$ etc
 an explanation that δ can be found using $A_n = A_0 \delta^{-n}$ must rely on
 values of A_n , A_0 and n that are determined using the line in **Figure 4**

2

[15]

Q2.

(a) 1.5 (ms) ✓

1

(b) $A = 4.2$ (mm) read from graph ✓

$T = 2.0$ (ms) read from graph ✓

$$(a_{\max} = 4.2 \times 10^{-3} \times (2 \times \pi / (2 \times 10^{-3}))^2$$

$$4.1(5) \times 10^4 \text{ (m s}^{-2}\text{)} \quad \checkmark \quad (\text{Do not allow } 4.2)$$

Condone power of ten error in A and/or T but not in final answer.

Evidence for T might be seen in equation, as 500 (f).

Only allowed ecf for max 2 is use of 4.1 mm for A , giving $4.0 \times 10^4 \text{ (m s}^{-2}\text{)}$

3

(c) longitudinal

(they) oscillate along direction of energy transfer ✓

Both required for 1 mark

Condone “vibrate” for oscillate.

Condone ‘travel’ for transfer

1

[5]