Mark schemes

Q1.

(a) $\lambda = 2 \times 0.648$

Allow 1296 (mm) or 1.296 (m) or 129.6 (cm) seen.

OR

Use of $v = f\lambda$ ✓

*Condone **one error** in their substitution where λ and f have been substituted and v would be the subject:*

Allow

(v=) 0.648 x 147 (forgets to double L)

OR

$(v=)\frac{0.648}{2}$ x 147 (halves L)

Do not allow:

*(v=) 648 x 147 (POT error **and** forgets to double L)*

NOR

$(v=)\frac{648}{2}$ x 147 (POT error **and** halves L)

(v =) 191 (m s^{-1}) ✓

Calculator display= 190.512

190 (ms^{-1}) correct to 2 sf

2

(b) Use of $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

OR

Use of $v = \sqrt{\frac{T}{\mu}}$

OR

*Condone **one error** where f, l and T have been substituted.*

OR

μ would be subject of a correctly rearranged expression $(\mu=)\frac{T}{4l^2f^2}$

(μ=) 1.956×10^{-3} (kg m^{-1})✓

Their l:

*must be seen in **MP1**:*

or

*condone a POT error (if already penalised in **MP1** or part (a))*

Use of

m = their μ × *their l* ✓

*allow ecf from part **(a)** where* $v = \sqrt{\frac{T}{\mu}}$ *seen*

MP1 $\mu = \frac{T}{v^2}$ *or* μ *= 71 / answer to part (a)*

MP2 *(m=) their ecf μ × 0.648*

MP3 ecf answer

(m =) 1.3×10^{-3} (kg) ✓

Calculator display= $1.267618831 \times 10^{-3}$ (kg)

3

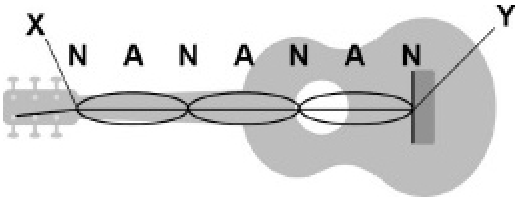
(c) At least one NAN envelope with its nodes N and antinodes A labelled.

OR

The positions of all nodes N and all antinodes A labelled✓

3 (NAN) envelopes drawn✓

All 3 envelopes drawn same dimensions and all nodes N and antinodes A labelled correctly ✓



Must not have any obvious differences in height and width by eye.

MP3: *Do not allow unequal width* ***and*** *unequal height.*

Penalise ***A*** *labelled twice at one antinode in* ***MP3.***

3

(d) **MP1**

Node at the midpoint

MP2

Idea that stationary wave can only exist if one of its nodes coincides with midpoint.

OR

Idea odd harmonic(s) require(s) an antinode to exist at this point and therefore cannot exist.

OR

Idea that the frequency f_2 (~)300 Hz can exist (when string is touched lightly at midpoint)

OR

Idea that the frequency f_4 (~)600 Hz can exist (when string is touched lightly at midpoint) (about 600 Hz)✓

__ECF__ from __(c)__ where third harmonic drawn with node at midpoint.

__MP1__ node at midpoint (ecf)

__MP2__ idea that one of the even harmonics, would have an antinode here and can't exist (ecf)

OR

idea that one of the odd harmonics can exist, would have a node here (ecf)

__MP3__ f_1, f_3 and f_5 all exist. (ecf)

Alternative __MP2__

Determines longest wavelength that can form stationary wave between __X__ and __Z__ (or equivalent) to arrive at 294 Hz (allow ecf from speed __(a)__)
OR
Determines next longest that can form stationary wave between __X__ and __Z__ (or equivalent) to arrive at 588 Hz (allow ecf from speed __(a)__)✓

MP3

f_2 and f_4 are both present.

OR

2nd and 4th (harmonics) are both present.

OR

The harmonics in **Fig 4** have double the frequency✓

Alternative __MP3__

both frequencies calculated. (allow ecf from speed in part __(a)__) ✓

Treat any reference to change in amplitude as neutral.

Compensatory mark max one: Condone a discussion in terms of two strings (or one-half vibrating) e.g. even harmonics are present.

3

[11]

Q2.

(a) 3.5 mm ✓

Accept 3.4 to 3.6

1

(b) Evidence of use of $v = f\lambda$ including 625 (Hz) ✓

Uses wavelength = 0.7 m to get 440 (m s^{-1}) ✓

Allow range of 0.68 - 0.72 m in λ or 425-450 m s^{-1}

2

(c) In phase OR 0 ✓

Accept 2π, 360^{o} and multiples

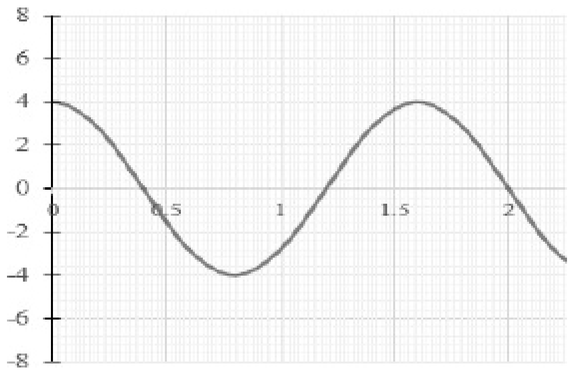
1

(d) Sinusoidal wave starting at displacement = 4 mm ✓

Amplitude = 4 mm ✓

Period (= 625^{-1}) = 1.6 ms ✓

Tolerance on drawing: half a square



Judge shape of wave on their first complete cycle.

If there is no complete cycle, the line they have drawn must cover the width of the grid.

3

[7]

Q3.

The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Mark	Criteria
6	All 3 areas covered in some detail. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
5	A fair attempt to analyse all 3 areas. If there are several errors or missing parts, then 5 marks should be awarded.
4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be several gaps, there should only be an occasional error.
3	One area discussed and one discussed partially, or all 3 covered partially. There are likely to be several errors and omissions in the discussion.
2	Only one area discussed or makes a partial attempt at 2 areas.
1	None of the 3 areas covered without significant error.
0	No relevant analysis.

The following points are likely to be present.

Area A (unpolarised)
- **Oscillations (or vibrations)** of particles / fields perpendicular to direction of energy propagation
- wave's **oscillations** (or vibrations) exist in more than a single plane

Area B (polarisation)
- (only) transverse waves can be polarised
- (oscillations) restricted to a **single plane**
- *where the plane and direction of propagation are coplanar / labelled diagram seen indicating polarised wave's oscillation in single plane and perpendicular to the direction of propagation.*

Area C (polaroid)
- Polaroid sunglasses absorb the horizontal component of the light / the light reflected from the water's surface is (nearly all) absorbed by Polaroid sunglasses.
- Polaroid transmits the **vertical component** of the light from submerged objects.
- because the light from the submerged objects is unpolarised **50% passes** through sunglasses to the eye.
- Idea that reduces surface reflection more than light from submerged objects.

[6]

Q4.

(a) attempts to calculate energy stored during 2.6 hr period

OR

attempts to calculate average output power during
12 hr period using their energy stored $_1$ ✓

Correctly rounded answer gains both marks.
(Calculator value is = 2.16666667)

For $_1$ ✓ stored energy = 93.6 kJ

For $_1$ ✓ condone use of t in hours. (2.6 hr = 9360 s; 12 hr = 43200 s)

2.2 (W) $_2$ ✓

If no other mark given, award 1 mark for calculating charge transfer during 2.6 hr period as 18.7 kC

2

(b) Max 2 from: ✓ ✓

microwaves are transverse; sound are longitudinal;

microwaves have higher frequency than sound;

microwaves can be polarised but sound can't;

microwaves can travel through a vacuum but sound can't/requires a medium **OR** sound are mechanical waves but microwaves are EM waves

Apply list principle. Do not allow reference to applications e.g. cooking food.

For first point, allow weak descriptions in terms of parallel and perpendicular oscillations/vibrations with direction of energy transfer.

2

(c) fixed/constant phase difference $_1$ ✓

same frequency $_2$ ✓

For $_1$ ✓ do not accept "in phase" or fixed <u>path</u> difference.

For $_2$ ✓ condone "same wavelength".

Ignore reference to other features e.g. amplitude or type of wave.

2

(d) evaluates **AM** from $\mathbf{AM}^2 = 8.00^2 + 0.34^2$

OR evaluates **BM** from $\mathbf{BM}^2 = 8.00^2 + 2.14^2$ ✓

8.28 − 8.01 = 0.27 (m) ✓

No credit for using double-slit equation.

*Expect 8.01 (m) for **AM** and 8.28 (m) for **BM***

2

(e) statement that path difference = λ/2 **OR** uses wavelength = 2 × their **part (d)** answer $_1$ ✓

Evaluates $\frac{340}{\text{correct }\lambda}$ (Hz) $_2$ ✓

For $_1$ ✓ expect to see 0.54 or 0.60 m for wavelength

*For $_2$ ✓ expect 570 Hz (from 0.3 m) **OR** 630 Hz (from 0.27 m) **OR** 620 Hz (from 0.274 m).*

If no other mark given, allow 1130 Hz or 1260 Hz. for 1 mark.

No credit for using double-slit equation.

2

[10]