Name: ______________________________
HR: ______________________________
Date: ______________________________
DP Physics

ISTANBUL INTERNATIONAL COMMUNITY SCHOOL
IICS SINCE 1911

Sound and Optics Review Markscheme

1. B **[1]**

2. C **[1]**

3. A **[1]**

4. D **[1]**

5. B **[1]**

6. D **[1]**

7. C **[1]**

8. B **[1]**

9. C **[1]**

10. A **[1]**

11. A **[1]**

12. (a) longitudinal; 1

(b) (i) wavelength = 0.5 m; 1

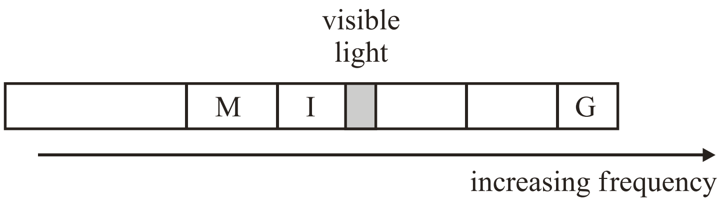
(ii) amplitude = 0.5 mm; 1

(iii) correct substitution into speed = frequency × wavelength;
to give $v = 660 \times 0.5 = 330 \text{ m s}^{-1}$; 2 max

[5]

13. (a) light consists of oscillating magnetic and electric fields at right angles to each other;
which transfer energy at speed c in vacuum (in a direction at right angles to both fields); 2

(b)



(i) correct labelling of infrared waves; 1

(ii) correct labelling of microwaves; 1

(iii) correct labelling of gamma rays; 1

*Award **[1]** if all positions are incorrect but order MIG is right.*

[5]

14. C

[1]

15. C

[1]

16. A

[1]

17. (a) diagram showing ray emerging along flat face; 1

(b) $\tan\theta = \frac{138}{120}$, $\theta = 49.0°$;
critical angle = 41.0°;
$n = \frac{1}{\sin C} = 1.52$; *(allow ecf if sensible)* 3

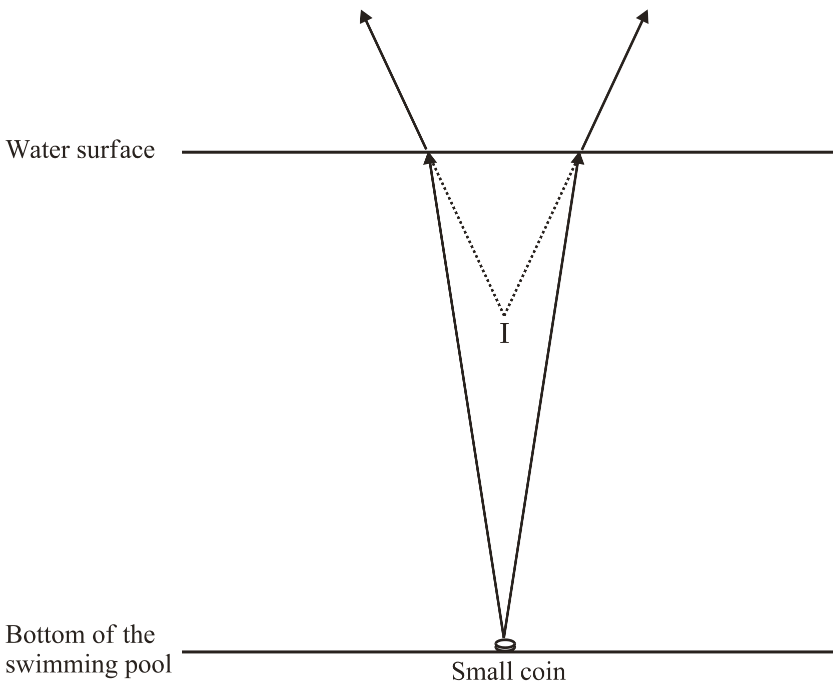
*Award **[1 max]** if the critical angle is = 49.0°*
(answer $n = \frac{1}{\sin C} = 1.33$).

(c) n is greater at higher frequency;
so C is smaller;
hence AB is larger; 3

*Award **[2]** if logic totally reversed.*

[7]

18. (a)



two rays from the coin showing refraction into the air;
extrapolated back to locate the labelled image **I**; 2 max

(b) virtual, since the rays form the coin to not come to a focus / *OWTTE*; 1 max

*Correct answer with wrong or weak or no explanation would receive **[0]**.*

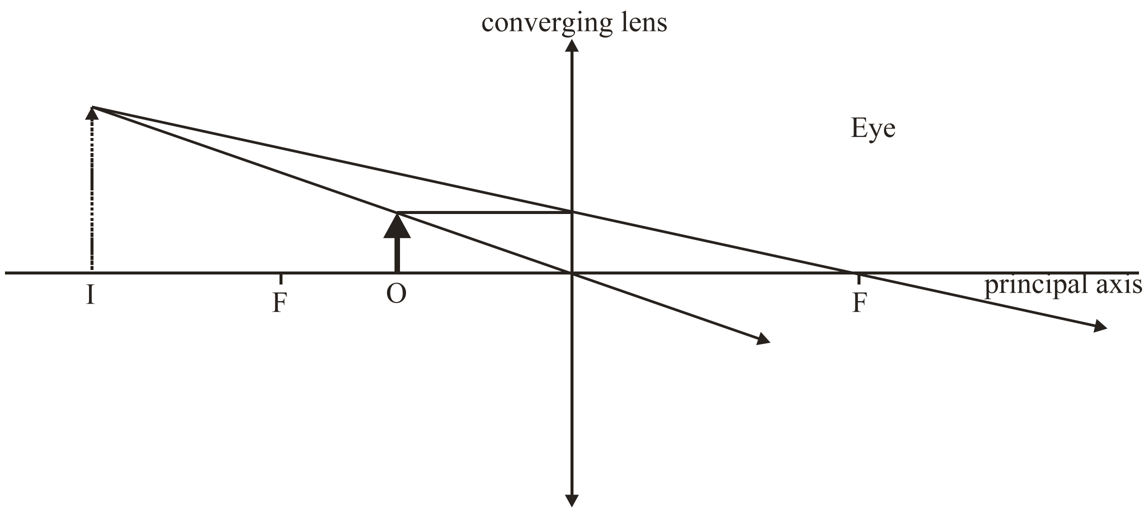
(c) $a = \frac{d}{n}$;

$= \frac{3.0}{1.3} = 2.3$ m;

distance from bottom of pool = 0.7 m; 3 max

[6]

19. (a)



(i) two appropriate rays; 1 max

(ii) correct image position; 1 max

(iii) eye to the right of the lens; 1 max

(b) (i) if the object is nearer than this to the eye then the eye cannot focus it clearly / *OWTTE*; 1 max

(ii) $\frac{1}{u} = -\frac{1}{v} + \frac{1}{f}$;

$v = -(25 - 3)\text{cm} = -22$ cm

$\frac{1}{u} = \frac{1}{22} + \frac{1}{10}$:

to give $u = 6.9$ cm; 4 max

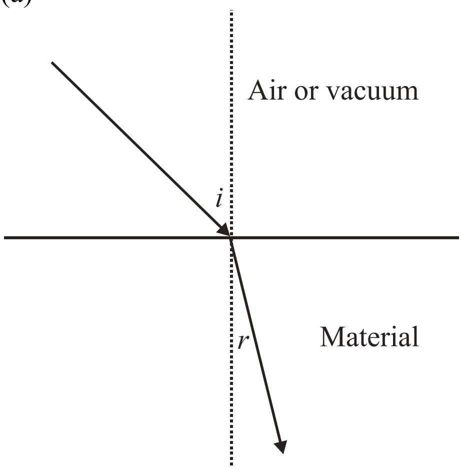
*Alternatively for scale drawing award **[1]** for scale, **[2]** for rays, **[1]** for position of image and **[1]** for subtraction.*

(iii) at the focal point;

the far point is at infinity; 2 max

[10]

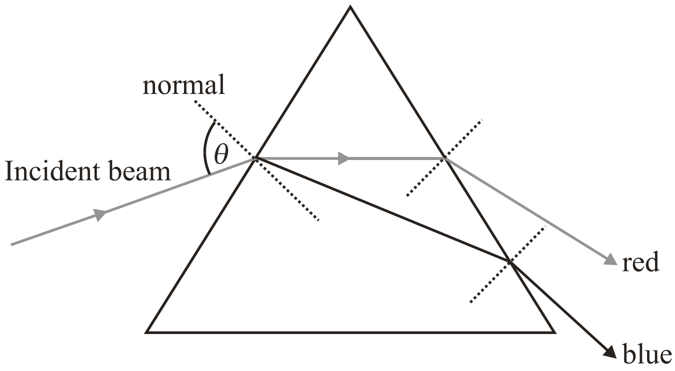
D«**20.** (a)



definition consistent with diagram $n = \frac{\sin i}{\sin r}$;

with i in air or vacuum; 2

(b) (i)



refraction at first surface;
refraction at emergent surface;
deviation greater than red light; 3

If the refractions are correct but the angle of refraction is less than that for red light award ***[2]***.

(ii) less — refraction angle is greater therefore sin i / sin r is smaller; 1

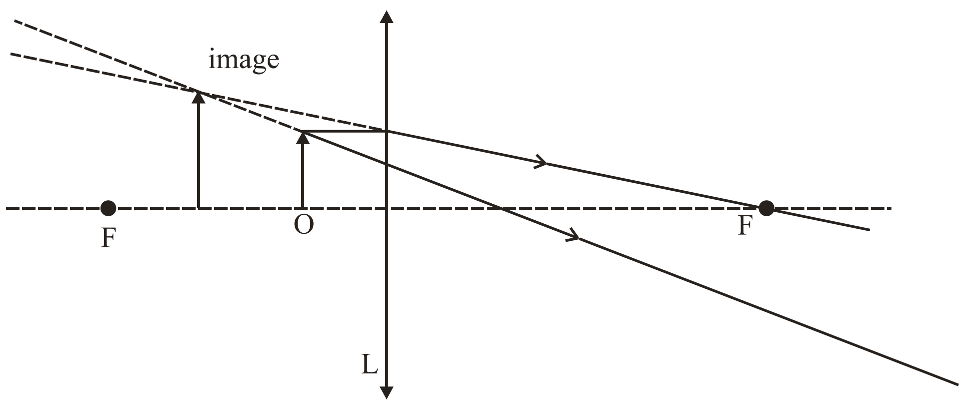
[6]

21. (a) distribution of colours;
separated according to wavelength / frequency; 2

(b) dispersion at both faces of prism;
refraction at both faces correct (by eye) – rays cross normal, $i > r$, $i < r$;
greater deviation for the blue than for the red; 3

[5]

22. (a)



(i) it is the point on the principal axis;
through which a ray parallel to the principal axis passes after going through the lens; 2

Award ***[0]*** *if focal point is defined as a distance.*

(ii) *Award* ***[2]*** *for any* **two** *appropriate rays and* ***[1]*** *for correct positioning of the image (upright).* 3

(iii) it is virtual because no rays pass through the image / cannot be formed on a screen; 1

Award ***[0]*** *if no explanation is provided.*

(b) (i) $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\dfrac{1}{v} = \dfrac{1}{6.25} - \dfrac{1}{5.0}$;

$v = –25$ cm, so distance is 25 cm; 2

Accept negative sign in answer for distance.

(ii) $M = \dfrac{v}{u}$

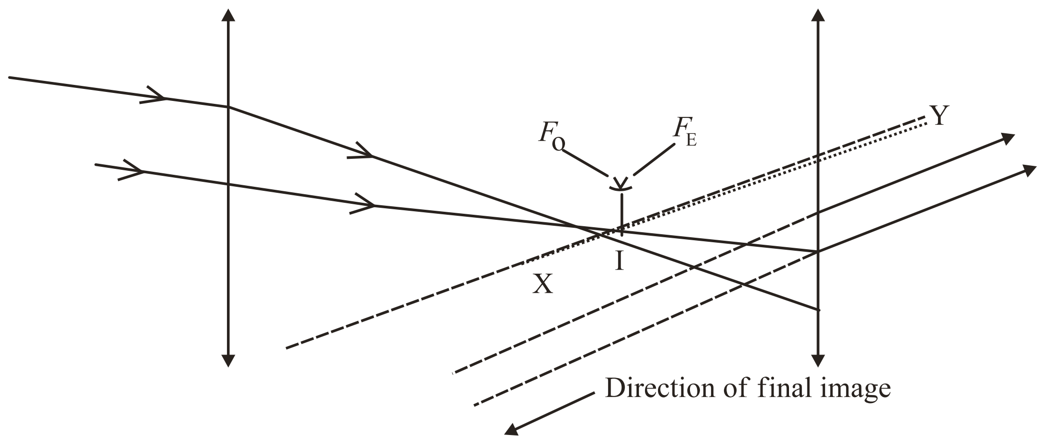
$M = \dfrac{-25}{5} = -5 \left(Accept\, M = -\dfrac{v}{u} = 5 \right)$

$L' = 5 \times 0.8 = 4.0$ cm; 2

[10]

23. (a) that point (on the principal axes) to which rays parallel to the principal axis; are brought to a focus after refraction at the lens / *OWTTE*; 2

(b)



(i) at F_O / other side of eyepiece; *(judge by eye)* 1

(ii) as shown on diagram; 1

(c) at infinity; 1 max

(d) two rays parallel to XY; *(judge by eye)*
extrapolated to show direction of final image; 2

(e) object distance $u = f_O + f_e = 100$ cm;

$$\frac{1}{v} + \frac{1}{100} = \frac{1}{f_e} = \frac{1}{2}$$

$$\frac{1}{v} = \frac{1}{2} - \frac{1}{100}$$ to give $v = 2.04$ cm;

beyond eyepiece lens / between eyepiece lens and eye;

or

scale drawing:

suitable scale;

object distance;

rays to locate image;

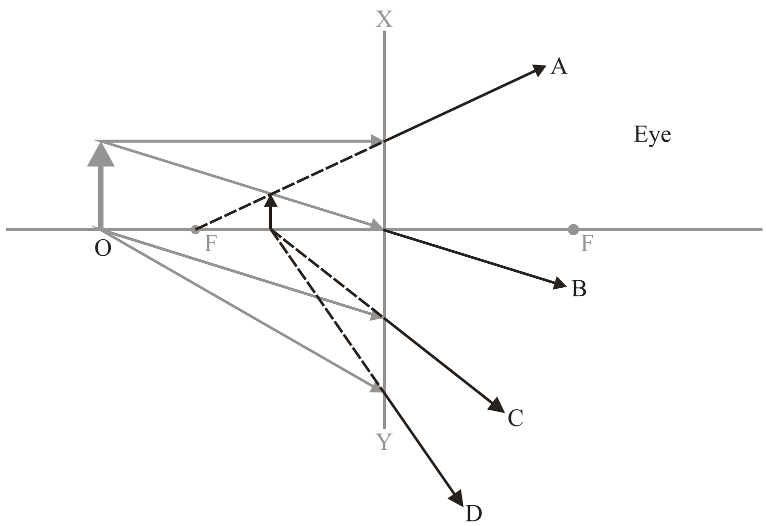
image distance 2 cm beyond eyepiece lens; 4 max

[11]

24. (a) focal point: the point on the principal axis to which rays parallel to the principal axis are brought to a focus after refraction by the lens / it is a point on the PA from which rays will be parallel to the PA after refraction by the lens; 2 max

*Look for a precise definition to gain **[2 max]** – award **[1]** for an inexact definition. Use discretion.*

(b) (i)



correct ray A;

correct ray B;

correct rays C and D;

correct location of the image; 4 max

*If a correct diagram is given for a **convex** lens award **[1]** but then use ECF for the rest of the question.*

(ii) anywhere to the right of the lens; 1

(c) virtual;

because any two rays from any one point of the object are not brought to a focus by the lens; 2 max

OWTTE;

*Virtual with incorrect explanation award **[1]** with no explanation **[0]**.*

(d)

Award marks either by calculation or drawing.

calculation:

use $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ with $f = -50$;

to give $v = -30.0$ cm;

to give $m = \frac{-30}{75} = -0.4$;

Only penalise once for incorrect sign.

drawing:

suitable scale;

correct rays;

correct measurement; 3 max

(e) no effect on linear magnification;

only effect on appearance is that image will be fainter; 2

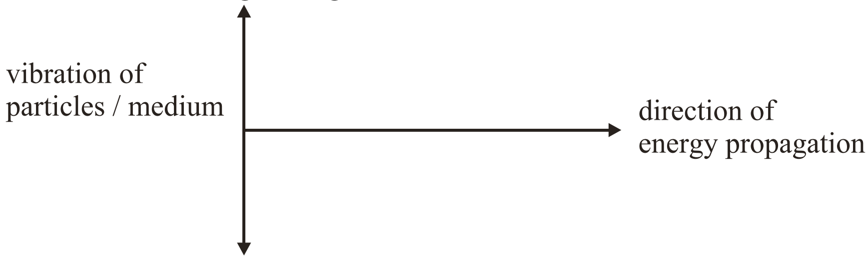
[14]

25. (a) a wave in which the direction of energy propagation;

is at right angles to the direction of vibration of the particles of the medium through which the wave is travelling / *OWTTE*; 2

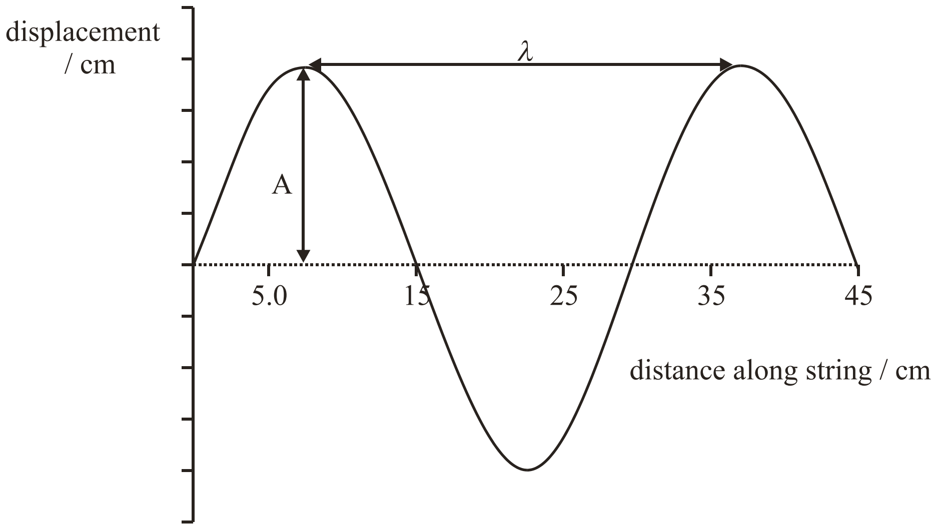
or

suitable labelled diagram e.g.



(b) any em wave / elastic waves in solids / accept water; 1

(c)



1

correct annotation

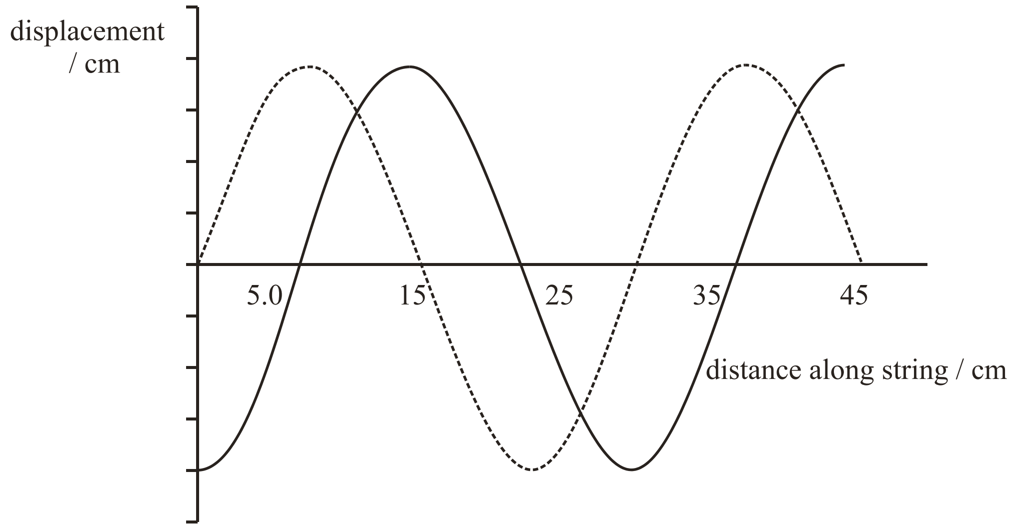
(i) A (4.0 cm); 1

(ii) λ (30.0 cm); 1

(d) $f = \frac{1}{T} = \frac{1}{1.2 \times 10^{-3}} = 830$ Hz;

$c = f\lambda = 830 \times 0.30 = 250$ m s^{-1}; 2

(e)



troughs / peaks moved to the right;
by λ /4 (7.5 cm); *(judge by eye)*
wave continuous between $x = 0$ and $x = 45$ cm; 3

(f) a system resonates when a periodic force is applied to it;
and the frequency of the force is equal to the natural frequency of vibration of the system / *OWTTE*; 2

(g) the string could be clamped at one end and vibrated at the other end by a signal generator / tuning fork;
whose frequency is adjusted until one loop of vibration is observed / *OWTTE*;
or
string is clamped at both ends;
and plucked in the middle; 2

(h) $\lambda = 0.90$ m;

$f = \frac{c}{\lambda} = \frac{250}{0.90} = 280$ hz; 2

[16]

26. (a) ray: direction in which wave (energy) is travelling;
wavefront: line joining (neighbouring) points that have the same phase / displacement /
Or suitable reference to Huygens' principle;
ray is normal to a wavefront; 3

(b) (i) wavefront parallel to D; 1

(ii) frequency is constant;
since $v = f\lambda$, $v \propto \lambda$;
wavelength larger in medium I, **hence** higher speed in medium I; 3

Allow solution based on angles marked on diagram or speed of wavefronts.

(iii) ratio = $\frac{v_I}{v_R} = \frac{\lambda_I}{\lambda_R}$ (or based on Snell's law);

$= \frac{3.0}{1.5} = 2.0$ *allow ± 0.5*; 2

(c) (i) velocity / displacement / direction in (+) and (–) directions;
idea of periodity; 2

(ii) period = 3.0 ms;
frequency = $\frac{1}{T}$ = 330 Hz; 2

(iii) *Accept any one of the following.*
at time t = 0, 1.5 ms, 3.0 ms, 4.5 ms, *etc*.; 1

(iv) area of half-loop = 140 ± 10 squares / mean $v = 4.0\text{ m s}^{-1}$ *accept ± 0.2*;
$= 140 \times 0.4 \times 0.1 \times 10^{-3}$ / $4.0 \times 1.5 \times 10^{-3}$;
$= 5.6 \times 10^{-3}$ m / 6.0×10^{-3} m; 2
*Award **[1]** for area of triangle.*

(v) (twice) the amplitude; 1
Allow distance moved in 1.5 m s.

(d) travelling wave transfers energy;
standing wave does not transfer energy;
amplitude same for all particles in a travelling wave;
amplitude varies from zero to a maximum in a standing wave; 4

(e) (i) distance shown as length of two loops; 1

(ii) wavelength = $\frac{2}{5} \times 120 = 48$ cm;
$v = f\lambda = 250 \times 0.48$;
$= 120\text{ m s}^{-1}$; 3

[25]

27. A

[1]

28. D

[1]

29. A

[1]

30. (a) circular wavefronts originating from four successive source positions;
bunching of wavefronts in front, spreading out at back;
approximately, correct spacing of wavefronts in front, and behind source; 3

(b) f waves in distance $(V - v)$;

apparent wavelength = $\dfrac{(V-v)}{f}$;

apparent frequency = $\dfrac{f \times V}{(V-v)}$; 3

*Allow any other valid and correct approach or statement of formula. Award **[0]** for quote of formula with no working shown.*

(c) $\lambda' = \lambda \dfrac{(V-v)}{V}$;

$599.996 = \dfrac{600 \times (3 \times 10^8 - v)}{(3 \times 10^8)}$;

$v = 2000\ \text{m s}^{-1}$; 3

Allow alternative version for red-shift.

[9]

31. (a) (i) energy transfer;
no interruption in transfer / without mass motion of the medium; 2
Do not accept "continuous".

(ii) speed / rate at which energy / wavefronts are propagated; 1

(b) (i) frequency: number of oscillations/vibrations <u>per unit time</u>; 1
Do not accept specific units e.g. seconds.

(ii) wavelength: distance moved by wave during one oscillation of the source; 1
Accept distance between successive crests or troughs.

(c) (i) wave travels down tube and is reflected;
incident and reflected waves interfere to give standing wave; 2

(ii) air (column) in tube has natural frequency of vibration;
when fork frequency equals natural frequency;
<u>maximum amplitude of vibration</u> / <u>maximum loudness</u>;
when fork frequency not equal to natural frequency,
no resonance / loudness drops; 4

(iii) $\frac{1}{2}\lambda = 65$ cm;

speed = $0.65 \times 2 \times 256 = 330\ \text{m s}^{-1}$; 2
*Award **[1 max]** for 660 m s^{-1}.*

(d) pressure = $\dfrac{\text{force}}{\text{area}}$

$= \dfrac{(4.0 \times 10^{-5})}{(30 \times 10^{-6})}$

= 1.3 Pa; 2

(e) (i) idea of using area under the line / $\frac{1}{2}kx^2$;

energy = $\frac{1}{2} \times 6 \times 10^{-5} \times 1.5 \times 10^{-2} \times 10^{-3}$ ***or*** 112.5 (±2.5) squares;

$= 4.5 \times 10^{-10}$ J; *(Allow $\pm 0.1 \times 10^{-10}$ if candidate counts squares.)* 3

(ii) period = 1.0 ms;
and energy is supplied in <u>$\frac{1}{4}$period</u> (= 0.25 ms);

power = $\dfrac{4.5\times10^{-10}}{0.25\times10^{-3}}$;

= 1.8×10^{-6} W; 4

(iii) strain energy / energy of deformation of eardrum / kinetic energy of eardrum / vibrational energy; 1

(f) (i) path difference is 2.5 λ;
wavelength = 0.20 m;
speed = $f\lambda$ = 1700 × 0.2 = 340 m s^{-1}; 3

(ii) at X: loudness increases;
waves not same amplitude at X so not complete destructive interference;
at P: loudness decreases;
because sum of amplitudes less than before; 4
*Award **[1]** for two correct statements without explanations.*
*Award **[0]** for statement with incorrect reasoning. Award **[1]** for correct statement with partially correct reasoning.*

[30]

32. Wave properties

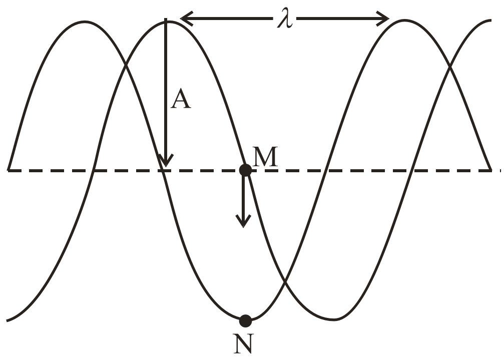
(a) (i)

1

(ii)

1

(b)



(i) downwards; 1

(ii) correct marking of A; 1

(iii) correct marking of λ; 1

(iv) +ve sine curve;
correct position of N; 2
Watch for ecf from (i).

(c) (i) $f = \dfrac{v}{\lambda}$ = to give 2.0 Hz; 1

(ii) $T = 0.5$ s;

$s = \dfrac{vT}{4}$ = 1.25 (1.3) cm;

or

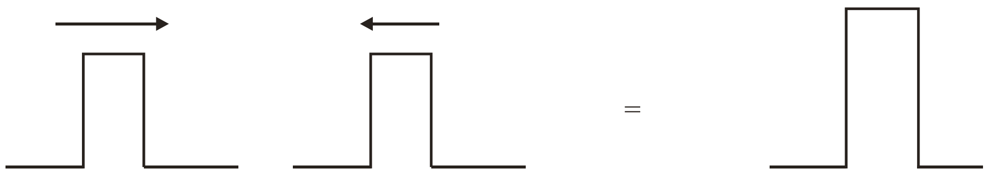
in $\dfrac{T}{4}$ wave moves forward $\frac{1}{4}\lambda$;

$= \dfrac{5}{4}$ = 1.25 (1.3) cm; 2 max

(d) *Principle of superposition*:
when two or more waves overlap, the resultant displacement at any point;
is the sum of the displacements due to each wave separately / *OWTTE*;

*Award **[2 max]** for an answer that shows a clear understanding of the principle, **[1]** for a reasonable understanding and **[0]** for a weak answer.*

Explanation:



suitable diagram;
when two +ve pulses (or two wave crests) overlap, they reinforce / OWTTE; 4

Any situation where resultant displacement looks as though it is the sum of the individual displacements. Mark the description of the principle and the description of constructive interference together.

(e) (i) $S_2X = n\lambda$;
where n = 0, 1, 2; *(Accept "n is an integer")* 2

(ii) $\sin\theta \approx \theta$;
therefore $\theta = \dfrac{S_2X}{d}$; 2

(iii) $\phi = \dfrac{y_n}{D}$; 1

Award the small angle approximation mark anywhere in (i) or (ii).

(f) (i) $\theta = \dfrac{S_2X}{d} = \dfrac{n\lambda}{d}$ *so* $\lambda = \dfrac{d\theta}{n}$;
substitute to get $\lambda = 4.73 \times 10^{-7}$ m; 2

(ii) θ and ϕ are small;

therefore $\frac{\lambda}{d} = \frac{y}{D}$;

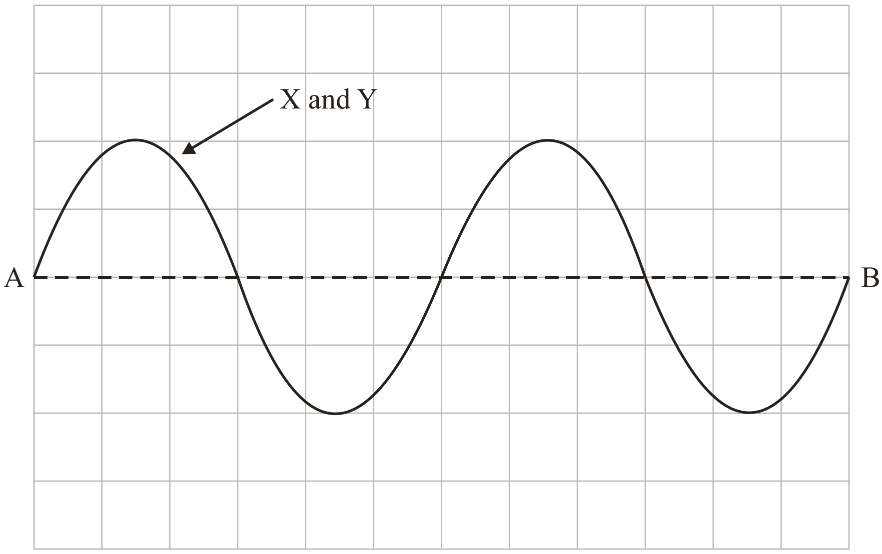
so $y = \frac{D\lambda}{d} = 0.510$ mm; 3

[24]

33. (a) the net **displacement** of the medium/particles (through which waves travel);
is equal to the sum of individual **displacements** (produced by each wave); 2 max

*Award a good understanding **[2 max]** and a reasonable one **[1 max]**.*

(b) *Wave X and wave Y should be identical.*



correct phase for wave X;
correct phase for wave Y;
amplitudes the same for each wave;
amplitude for each wave is two divisions; 4 max

(c) (i) the phase difference between light leaving S_1 and S_2 is constant; 1

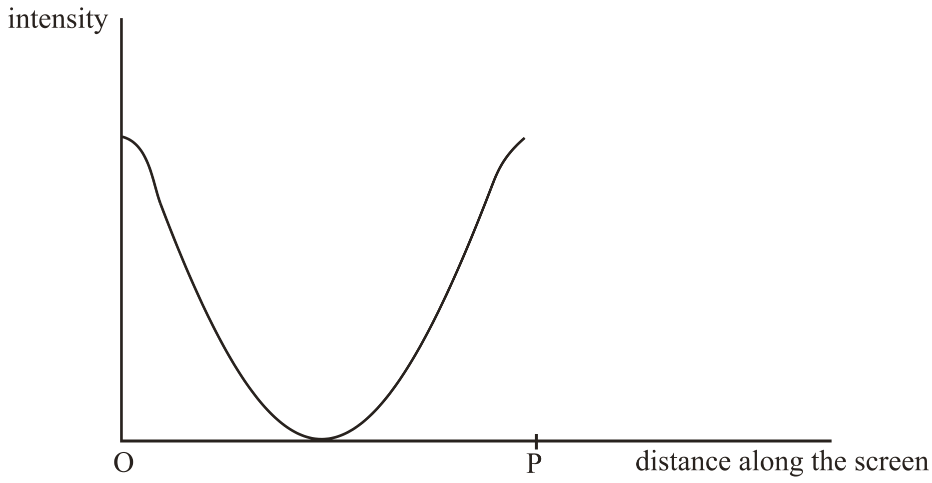
Do not penalize the candidate if they state "has the same phase".

(ii) to produce **sufficient** diffraction;
for the beams to overlap;
OWTTE; 2 max

(d) (i) path difference between S_1 and S_2 is an integral number of wavelengths; 1

Accept "waves arrive at P in phase".

(ii)



maximum at O and P;
general shape with minimum about half way between O and P; 2 max

(e) fringe spacing = 2.5×10^{-4} m;

$\lambda = \dfrac{(2.5 \times 10^{-4} \times 3.00 \times 10^{-3})}{1.50} = 5.0 \times 10^{-7}$ m; 2

[14]