1.(a) (i) recall of R.I = c_i / c_r OR $3.00 \times 10^8 / 2.25 \times 10^8$ C1
= 1.33 (OR 1.3) A1 [2]
{NB award 1 mark only for a bare 1.3 but 2 marks for a bare 1.33 OR 4/3 OR 11/3 }

(ii) recall of R. I. = sin i/sinr C1
(1.33 = sin40/sinr, hence) $r = 29^o$ (expect 28.9) A1 [2]
{NB allow ecf from (i) e.g. for n=1.3 $r = 29.7$ or 30^0}
{NB watch out for $40/1.3 = 30.7^o$ being offered as the answer!}

(b) (i) Shown on Fig.1.1:
ray travelling towards air from water arrow(s) must be shown B1

ray shown travelling along {*or just above*} water surface B1

valid C correctly labelled B1 [3]
{do not penalise or reward presence of partially reflected ray}

(ii) use of RI = 1/sinC:
e.g. sinC = 1/n OR sinC =1/1.33 OR 1.33 = 1/sinC) C1
$C = 49^o$ A1 [2]
{allow ecf from (i) e.g. for n=1.3 C = 50.2 or 50^0}

TOTAL: 9

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2. (a) spreading (out of waves as they pass through an opening or an edge) - B1 [1]
{NB ignore bending/changes direction/deviates/disperses}

(b) (i) (circular) arcs drawn after gap: i.e. reject any flatness B1

(ii) waves must have plane central section {ignore curved edges} B1

evidence that wavelength stays constant shown in either diagram B1
{judged by eye unless λ is labelled before and after gap}

Gap widths look about right w.r.t. λ i.e. x2 and x10 - generously
judged by eye, looking at (i) first then comparing gap size with (ii). B1 [4]

(c) Wavelength of light is very short B1
most gaps are very large in comparison to wavelength OR small gaps
are needed (to observe diffraction) (AW) B1 [2]

TOTAL: 7

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3. (a) (i) amplitude = 1.2 (mm) B1 [1]

(ii) period = 2.4 (ms) B1 [1]
{allow 2.4×10^{-3} ms if 2.4×10^{-3} is correctly used in substitution in b(i)}

(b) (i) frequency = 1/period C1
1/0.0024 = 417Hz (OR 420) A1 [2]
{1/2.4 = 0.417 OR 0.42 OR 0.4 scores 1 mark}
{allow ecf from cand's period value}

(ii) recall of $v = f\lambda$ OR $c = f\lambda$ OR $\lambda = vT$ OR $1500 = 417\lambda$ C1
$\lambda = 3.6$ m A1 [2]
{ecf for cand's f: e.g. $\lambda = 1500/0.417 = 3600$ m scores 2 marks
OR $\lambda = 1500/0.4 = 3750$ m scores 2 marks}
$\lambda = 1500/0.42 = 3571$ m scores 2 marks

(iii) valid scale for cand's λ shown on position axis AND at least two full 'sine' waves drawn (waves can be very rough but not square waves } B1

amp. shown as 1.2 mm +/- ½ sq.:check first peak + trough only B1

first wavelength correct as 3.6 m +/- 1 sq.{allow ecf from (b) (ii) } B1 [3]
{NB If there is no scale on the position axis the 1st and 3rd marks cannot be scored}

TOTAL: 9

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4. (a)

- Reference to incident & reflected waves or formation of a *standing wave* :e.g. detector receives waves directly from T and (by reflection) from P }
OR reflected wave interferes with outgoing wave (AW) } B1
OR a" standing wave" OR "nodes AND antinodes" formed }

waves interfere constructively for maxima OR destructively for minima}
OR *nodes formed where intensity is minimum OR antinodes at maxima*} B1

- Measure distance between maxima/minima OR *between nodes/antinodes* B1
evidence of max to max/min to min/node to node/antinode to antinode = 1/2λ B1

- Use $v=f\lambda$ to find f B1
evidence that v is known to be speed of light /c/3×10^8m/s B1
{NB allow answers referring to CRO: find period from CRO trace -- M1; use f=1/T – A1} [6]
{NB: "use $c=f\lambda$" scores 2 marks "use a (digital) frequency meter scores 1 max}

(b) Place (polarising) grid (allow "POLAROID") between T and D AND ROTATE M1
{allow 'rotate transmitter' OR 'rotate detector' }
signal drops to zero if microwaves are plane polarised A1 [2]
{NB: "Rotate a SINGLE-slit AND signal drops to zero" scores maximum of 1 mark}

TOTAL: 8

5. (a) when two waves meet/overlap/interfere/collide/superpose (AW) B1
the resultant displacement is the sum of the displacements B1 [2]
{do not allow amplitude}
{NB allow 2 marks for good diagrams}

(b) (i) wave sources with constant phase difference B1 [1]
{NB allow "in phase" and ignore reference to frequency/wavelength/amplitude}

(ii) S_1 and S_2 'share the same light' (AW) B1

reference to diffraction at the single slit
OR to wavefronts e.g. "same wavefront reaches S_1 and S_2 (AW) B1 [2]

(iii) Constructive interference occurs at O B1
path difference is zero OR waves meet in phase (AW) B1 [2]

(iv) recall of formula $\lambda=ax/D$ in any valid form (e.g. $x = \lambda D/a$) C1
{NB allow undefined symbols provided they match the above as stated in the spec., otherwise they must be defined}

correct sub. with consistent units: $\lambda = 2 \times 10^{-3} \times 0.6 \times 10^{-3} / 1.8$ C1
$\lambda = 6.7 \times 10^{-7}$ m A1 [3]
{NB allow ecf if mm used: i.e 2 marks for 6.7×10^{-1} OR 6.7×10^{-4}}

(v) 'fringe separation' (AW) would DECREASE B1
{NB allow "more fringes would be seen"}

because $x \propto \lambda$ (AW) B1 [2]

{NB allow 'colour change' arguments for full marks:
Colour would change B1;
to a colour closer to the blue end of visible spectrum (AW) B1}

TOTAL: 12