1. (a)   symbol c represents speed of light/wave --M1
       c_i = speed of light in air/vacuum (or speed of incident ray or WTTE) **AND**
       c_r = speed of light in medium (or speed of refracted ray or WTTE) -----------A1   [2]

     (b) (i) recall of R.I = sini/sinr -- C1
         correct substitution into this formula : e.g. 1.47 = sin 50/sinr ----------------- C1
           r = 31 (or 31.4 or 31.42) degrees -- A1
(NB 50/1.47 = 34.01)

         (ii) r = 0 degrees --- A1
                                                        [4]

                                                                        [6]

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2. (a) (i) labelled diagram with light from dense to less dense medium (or stated)   B1
       critical angle correctly labelled: refracted ray on surface (arrows not needed)--   B1
       {written description with no diagram scores 1 mark max).   [2]

       (ii) ray shown to be INTERNALLY reflected (ignore angles, arrows not needed)   B1
          diagram with incident angle > than critical angle and symmetrical (by eye)-   B1
       {written description with no diagram scores 1 mark max).   [2]

     (b) valid <u>substitution</u> in RI = 1/sinC: e.g. 1.76 = 1/sinC ---------------------------   C1
          C = 35 (or 34.6) ° ---   A1   [2]

                                                                       [6]

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3. (a)   (i) any valid example - e.g. LIGHT, MICROWAVES (any em waves) ------   B1 [1]
          (allow "water" /"sea" but reject 'slinky' unless explained/shown)

       (ii) any valid example: e.g. SOUND --B1 [1]
       (allow 'pressure wave'; reject "water" and 'slinky' unless explained/shown)

    (b)(i) *transverse* = vibrations perpendicular to wave (direction) (WTTE) -----------B1 [1]
       (allow "motion is perpendicular to wave", reject vague answers: e.g "vibrate up+down")

       (ii) *longitudinal* = vibrations parallel to wave direction (WTTE) -------------------- - B1 [1]
       (allow "motion is perpendicular to wave" reject vague answers: e.g "vibrate back and for)

Wave phenomenon	Transverse waves	Longitudinal waves		
REFLECTION	YES	YES		
REFRACTION	**YES**	**YES**	B1	
DIFFRACTION	**YES**	**YES**	B1	[3]
POLARISATION	**YES**	**NO**	B1	

                                                                       [7]

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4. (a) (i) amplitude correctly labelled (by **A** or in words) ------------------------------ B1 [1]
(reject "A" as a point i.e. with no arrows)

(ii) wavelength correctly labelled (by λ or in words) -------------------------- B1 [1]

(b) (i) same shape --- B1
moved slightly to the right consistently drawn for both waves -------------- B1 [2]
(do not allow shift of more than ¼ wavelength)

(ii) movement is VERTICAL --- M1
Q moves UP ↑ AND S moves DOWN ↓ shown ----------------------------- A1 [2]

(c) phase difference = 180° (degrees) OR π ------------------------------------ B1 [1]
{allow "in antiphase" do not allow "out of phase"}

(d) (i) recall of T = 1/f --- C1
T = 1/25 = 0.04 s --- A1 [2]

(ii) recall of v= fλ --- C1
valid substitution: e.g. v = 25 x .036 --------------------------------------- C1
v = 0.90 ms^{-1} --- A1 [3]
(there are 2 possible errors – incorrect wavelength and wrong units, so
v = 90 m/s scores 2 marks
v = 0.45 m/s scores 2 marks but allow 3 marks for ecf from cand's λ in (a) (ii)
v = 45 m/s scores 1 mark but allow 2 marks for ecf from cand's λ in (a) (ii)

(e) (i) any valid suggestion: e.g. change <u>depth of water</u> ----------------------------- B1 [1]

(ii) wavelength will reduce --- C1
halved
{OR new wavelength = 1.8cm OR half cand's value shown in (d) ii} --------- A1 [2]

[15]

5. (a) <u>COHERENT</u> (allow coherence) -- B1   [1]

(b) ***constructive interference:*** valid diagram and/or explanation: e.g.

when waves (from coherent sources) meet in phase (or $n\lambda$ path diff.) --------- B1
waves reinforce: resultant has increased displacement/amplitude -------------- B1
correctly shown on diagram or stated

destructive interference: valid diagram and/or explanation: e.g.
when waves meet in antiphase/180° phase diff. {or $(n+1/2)\lambda$ path diff.} --- B1
waves cancel: resultant has reduced displacement/amplitude --------------- B1
correctly shown on diagram or stated

[4]

(c) ***diagram***:
laser OR light source <u>and single-slit</u> in front of double slit ------------------ B1
screen (WTTE) (or travelling microscope) behind double-slit -------------- B1
(if 'screen' is not labelled mark can be obtained by reference to 'screen' in text)

measurements:
<u>measure</u> distance between double-slit and screen ------------------------------ B1
<u>measure</u> distance between neighbouring dark/bright images ---------------- B1
(allow 'fringe spacing' or measure distance for n fringes)

formula:
recall of $\lambda = ax/D$ --- B1

ALL symbols correctly defined
a = distance between slits --}
x = fringe separation (WTTE) ---} B1
D = distance between slits and screen ---}   [6]
(If candidate uses their own symbols they must be used correctly to score the formula recall mark)
(do not penalise careless use of d and D: i.e. being interposed)

[11]