1. (a)(i) *i* correctly labelled B1
r correctly labelled B1 [2]
{Allow 1 mark if i and r are transposed but ZERO marks if angles labelled from ray to surface}

(ii) $n = \sin i / \sin r$ B1 [1]
{correct answer only - i.e. ignore diagram and do not allow error carried forward}

(b)(i) *speed* : **decreases** B1
frequency: **stays the same** B1
wavelength : **decreases** B1 [3]

(ii) new speed = v/n *(OR* $f\lambda/n$ *OR* c/n *OR* $3\times10^8/n$*)* B1

new wavelength = λ/n (OR v/fn) B1 [2]
{The new speed and new wavelength must be the subject of the equations - i.e do not allow general expressions which appear to contain new values of v and λ. Simply stating v=fλ does not score any marks}

[TOTAL = 8]

2. (a)(i) **TOTAL INTERNAL REFLECTION** {allow TIR} B1 [1]

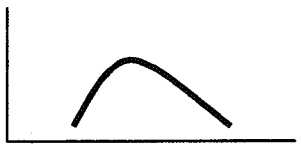
(ii) angle of **incidence GREATER** than the **critical angle** B1
R.I of core > R.I of cladding
OR density of core > density of cladding } B1 [2]
OR speed of light in core < speed in cladding
{Allow 2 marks if candidate simply states "θ > critical angle " provided he defines the meaning of the critical angle in words or in a diagram i.e. B1 + B1}

(b)(i) recall of $n = c_1/c_2$ C1
$c_{core} = 3\times10^8/1.48 =$ **2.03×10^8** (OR 2×10^8) ($m\ s^{-1}$) A1 [2]

(ii) valid substitution into t = d/v : e.g. t = **$900 / 2.03 \times 10^8$** C1
minimum time = **4.4×10^{-6}** s ***{allow ecf for v from b (i) e.g. 4.5×10^{-6}}*** A1 [2]

(iii) valid substitution into d = v x t: e.g. d = **$(2.03 \times 10^8) \times (45 \times 10^{-9})$** C1
extra distance = **9.1** (OR 9) m A1 [2]
{allow ecf for v from b (i) AND check that c_{core} - 2.03×10^8 -is used}
{Many are calculating the total distance - $(4.4 \times 10^{-6} + 45\times10^{-9}) \times 2.03 \times10^8 = 902m$ - this scores the first C1 mark for a 'valid' substitution but they must subtract 900m to score the final mark - it will probably not be 9 m but apply ecf - in the example above it would be 2m}

(c)(i) intensity



pulse now **longer** M1
and **lower** (ie less intense) A1 [2]

(ii) different parts of pulse follow **diff.^{t} paths** OR ref. to "**multipath dispersion**" - M1
(hence) pulse spread over longer time (WTTE) A1 [2]
{Allow 1 mark for energy spread over longer time OR energy lost/absorbed B1}
{The words longer and shorter must be defined: eg longer time / longer path. Also allow "area under the graph stays the same}

[TOTAL = 13]

3. (a) *interfere destructively:* the resultant wave has **reduced** (or zero) **amplitude**
OR "waves cancel each other" OR shown on a diagram B1
conditions: waves must meet **180°** OR π OR **1/2** λ out of phase B1
OR in ANTI-phase 'crest of one meets trough of other' OR shown on diagram
waves must have **equal amplitude** (not 'coherent' or 'same frequency') B1 [3]

(b)(i) for maxima **path difference = 0** OR λ OR **n**λ C1
series of maxima occur at pts. where path diff = 0, λ, 2λ, 3λ, 4λ A1 [2]
(OR when n = 0, 1, 2 , 3 ... OR n is an integer)

(ii) $x = \lambda D/a$ (allow $\lambda = ax/D$ or any valid form) B1 [1]

(iii) ***x* DECREASES** C1
to **HALF** previous value A1 [2]
{Allow full ecf from incorrect formula - e.g "x $\propto$ a hence x doubles" gets 2 marks- but give full credit for expected answer even if the candidate has quoted an incorrect formula in (ii)!}

(c) wavetrains must be **coherent** (OR const phase diff/in phase OR same frequency) C1
an explicit reference to the SLITS or the TRANSMITTERS is needed: e.g.
two **transmitters would not** be coherent (WTTE)
OR **two slits in front of a transmitter** create coherent sources A1 [2]

[TOTAL = 10]

4. (a) **plane wavefronts** approaching a gap B1
'semicircular' (allow ANY spreading shape) wavefronts leaving the gap B1
no change of wavelength stated or shown (generously judged by eye) B1 [3]

(b) sound waves are **diffracted** B1
around the wall (OR spread out on other side of wall) B1 [2]
{Allow 1 mark for "sound is transmitted through the wall but light is not" OR "sound λ>>light λ and hence no diffraction of light"}

[TOTAL = 5]

5. (a) the coil moves at **RIGHT ANGLES** OR across pulse direction B1
and **OSCILLATES** (or WTTE) B1 [2]
{Allow 2 marks for fully labelled diagrams }

(b)(i) (air particles vibrate) **vertically** OR **up & down** OR **along tube** B1 [1]

(ii) **N** correctly labelled at the **base AND A** correctly labelled at the **top** B1 [1]

(iii) $0.4 = \frac{1}{4}\lambda \Rightarrow \lambda =$ **1.6 m** B1
recall of $v=f\lambda$ C1
f = 320/1.6 = **200 Hz** A1 [3]
{allow ecf for candidate's λ - expect to see 400 Hz or 800 Hz each of which scores 2 marks }

(iv) any other **valid** mode of oscillation: **N at bottom AND A at top** B1
all other **Ns AND As correctly labelled {allow ecf for cand's diagram}** B1 [2]

[TOTAL = 9]