1. (a) (i) i correctly labelled between incident ray and normal B1 [1]

(ii) refracted ray correctly drawn bending towards the normal B1 [1]

(b) (i) recall of R.I = c_i / c_r OR $3.0 \times 10^8 / 1.9 \times 10^8$ C1
= 1.58 (OR 1.6) A1 [2]

(ii) recall of R. I. = sin i/sinr C1
sini = $\sin 35^0 \times 1.58 \Rightarrow$ hence $i = 65^\circ$ (64.9 to 67) A1 [2]

{do not allow ecf for second mark if value of n is less than 1}

TOTAL = 6

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2. (a) angle (of incidence) must be greater than critical angle/C (WTTE) B1
light must be directed from dense to less dense medium (WTTE) B1 [2]

{do not allow" incident ray > C" }

(b) (i) RI = 1/sinC (OR sinC = 1/1.01) C1
C = 82o { allow 81o} A1 [2]

(ii) less multipath dispersion (WTTE) B1
because (virtually) all the rays follows same path (WTTE) B1
most of the light escapes B1
by refraction B1 [4]

TOTAL = 8

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3. (a) (i)	any 3 from reflection, TIR, refraction, diffraction, interference {also allow energy transfer, superposition, creation of standing waves but do not allow $v=f\lambda$, progressive waves}	B1+B1+B1	[3]
(ii)	polarisation	B1	[1]
(b) (i)	frequency = number of vibrations/waves/oscillations/cycles per sec {reject f=1/period unless period defined}	B1	
	wavelength = distance between neighbouring corresponding pts {Allow "crest to crest" "trough to trough" or labelled diagram or length of 1 cycle of the wave}	B1	[2]
(c)	in one second f waves are produced each of length λ	B1	
	distance travelled in one second is therefore $f\lambda$ OR (hence) $v = f\lambda$	B1	[2]
	OR speed = dist/time = λ/T	B1	
	and $T = 1/f$ hence $v= f\lambda$ {reject consistency of units approach}	B1	
(d) (i)	period = 1/500 = 0.002s (or 2ms)	B1	[1]
(ii)	at least 2 full (sine) waves of constant period (+/- 2mm)	B1	
	of amplitude 3 cm (+/- 2mm in both directions)	B1	
	correct 'period' of 4 cm (+/- 2mm throughout)	B1	[3]
(iii)	correct substitution into $v=f\lambda$: e.g. $330 = 500\lambda$	C1	
	$\lambda = 0.66$ m {do not allow 0.6 but allow 0.7}	A1	[2]
		TOTAL =	14

4. (a) similarity: any valid point e.g. (both have) vibrations, frequency, amplitude, wavelength, period, displacement (not velocity) B1
difference:
e.g. no energy transfer for standing waves }
neighbouring points vibrate in phase for standing waves } B1
only standing waves have nodes and antinodes } [2]
{allow standing waves are "trapped"/fixed/confined/don't move forward}

(b) (i) arrows show vertical oscillations B1
maximum amplitude at top {allow ecf for horiz.} B1
less in middle AND very small (or zero) at base B1 [3]
{allow 1 mark only for unlabelled diagram showing representation of amplitude}
{2 marks for unlabelled diagram plus an arrow}
{allow single headed arrows}

(ii) wavelength = 4 x 0.36 = 1.44m B1 [1]

(iii) recall of $v = f\lambda$ B1
$f = v/\lambda$ = 330/1.44 (allow ecf) = 229 (or 230) Hz B1 [2]

(iv) if open at both ends each end must be an antinode OR diagram B1
hence wavelength = 0.72m {allow ecf} C1
and frequency = 458 (or 460) Hz {allow ecf} A1 [3]

TOTAL = 11

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5. (a) (i) a progressive wave transfers energy (WTTE) B1 [1]
{allow "wave profile moves through space" OR crest/troughs move along the medium}
{allow "waves that move from one place to another" but not "waves move"}

(ii) longitudinal: vibrations/motions PARALLEL (to wave direction) B1
{allow back and forth}
transverse: vibrations/motions PERPENDICULAR (to wave direction) - B1 [2]

(b) a straight object vibrated in the water (WTTE) B1

REDUCE FREQUENCY of wave source B1
{allow 'increase the depth of the water'}
REDUCE DEPTH of water in the tank B1 [3]

TOTAL = 6