ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme. You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

x	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

1. (a)(i) R.I. = ratio of speeds – allow symbols C1
$c_g = 3 \times 10^8 / 1.52 =$ **1.97×10^8** m s^{-1} A1 **[2]**

(ii) $c_w = 3 \times 10^8 / 1.33 =$ **2.26×10^8** m s^{-1} A1 **[1]**

(iii) ${}_wn_g = c_w / c_g$ {OR n_g / n_w} C1
$= 2.26 \times 10^8 / 1.97 \times 10^8 =$ **1.15** {ecf from (i) and (ii)} A1 **[2]**
{OR ${}_wn_g = 1.52/1.33$ C1 hence ${}_wn_g =$ **1.14** A1}

(iv) $\sin C = 1/{}_wn_g$ {not just sinC = 1/n} (OR $\sin C = {}_gn_w$) C1
$C = \sin^{-1}(0.877) =$ **61.3°** OR 61° - {ecf provided C < 90°} A1 **[2]**
{if 1.14 value is used C = **60.4°** OR 60°}

(v) diagram showing **ray** travelling from **glass to water** B1

refracted **ray** drawn **along interface** {allow water to glass direction} B1
{ignore any reflected rays drawn}

'valid' critical angle labelled **C** i.e refracted ray drawn along interface B1 **[3]**

(b)(i) idea/inference that rays will take **different paths**: e.g. some light will enter at different angles OR SOME light will be internally reflected OR SOME rays will take a 'zig-zag' path (WTTE) allow diagrams B1

this will cause some parts to **travel further** than others (WTTE) B1

some of the rays will arrive **sooner** than others (WTTE) B1 **[3]**

(ii) ANY valid suggestion plus explanation: B1 + B1: e.g. **[2]**

use **'STEP-INDEX'** fibre (OR coat fibre with cladding of LOWER R.I.) B1
this **increases the critical angle** OR reduces number of reflections B1
OR
use **'MONOMODE'** fibre (OR very thin fibre) B1
this only allows **light to travel down the centre** (WTTE) B1
OR
use **'GRADED-INDEX'** fibre B1
this **reduces number of reflections** OR increased velocity towards edge compensates for extra distance travelled B1

Allow 2 marks for 2 valid suggestions without explanation.

QUESTION TOTAL = (15)

2. (a)(i) longitudinal = vibrations in **same direction as wave** (WTTE) B1

transverse = vibrations at **90° to wave direction** (WTTE) B1 **[2]**

{accept any word implying vibration e.g. oscillations / movements}
{Allow 1 mark only for longitudinal = compressions and rarefaction
AND transverse = crests and troughs}
Allow 1 mark for imprecise comparison e.g. using the word 'travel'}

(ii) ANY THREE valid phenomena: B1 + B1 + B1: e.g. **[3]**
REFLECTION REFRACTION DIFFRACTION
INTERFERENCE OR Superposition' OR 'Coherence' OR Standing waves
Allow "both convey/transfer energy" but reject "both obey v=fλ" or both have a frequency, wavelength or velocity

(iii) **POLARISATION** B1

relevant diagram: e.g. showing unpolarised radiation with vibrations in many planes OR plane polarised light blocked by a polariser at 90° B1

explanation: e.g. statement/diagram showing polarised radiation

OR explanation of why polarisation is impossible for longitudinal waves B1 **[3]**

(b)(i) each wave/cycle occupies **4** (squares or cm) C1
{allow "wavelength" = 4cm}

which represents **40 ms** (OR period = 40 ms) C1

frequency = (1/0.04) = **25** Hz A1 **[3]**

{0.025Hz scores 2 marks if valid reasoning is offered above}

(ii) trace **more spread out** stated or implied B1

idea of '**time shorter or speed of trace faster**' B1

only ¼ **of a wave** shown on the screen B1 **[3]**
OR wave now 10 times longer (WTTE)

(iii) $v = f\lambda$ C1

$\lambda = 330/25$ {allow ecf from (i)} C1

= **13.2** m A1 **[3]**

QUESTION TOTAL = (17)

3. (a)(i) a **SMALL object** /dipper is vibrated (up and down) (WTTE) B1 **[1]**
OR narrow slit(s) placed in front of vibrating source/plane waves
{look at diagram drawn in (iii) to reinforce this answer}

(ii) the two 'dippers' are attached to the **SAME vibrating strip** B1
OR two slits placed in front of a plane wave

Sources in phase OR **constant phase relation** OR same frequency B1 **[2]**

{cands. Might answer (ii) in (i): give credit for correct answers shown anywhere}

(iii) diagram showing at least **3 interference 'lines'** B1

2 correct constructive points shown as **Cs** on lines of 'circles' B1

2 correct destructive points shown as **Ds** on line of 'circles' B1 **[3]**

(b)(i) correct parameters defined: {allow any symbols but expect the following}

a = distance between slits
x = dist. Between neighbouring maxima (or minima) (OR 'fringe sep.') } B2
D = distance between slits and screen (or detector)

{deduct 1 mark for each error/omission stop at zero !}

valid formula for candidate's symbols: $\lambda = ax/D$
OR vernier calipers OR micrometer B1 **[3]**

(iii) slit separation: **0.1 to 2.0 mm** B1

distance to screen: **0.2 m to 10.0 m** B1

fringe separation **0.5 mm to 20 mm** B1 **[3]**

QUESTION TOTAL = (15)

4. (a) any ***similarity of particle motion*** : e.g. particles vibrate in **same direction as wave** OR vibrate **longitudinally** B1

any ***TWO differences of particle motion*** : B1 + B1 e.g.:

all particles have **same amplitude in progressive** wave
(but particles have different amplitude in standing wave) (WTTE)

OR
in a **standing wave there are particles that don't move** (but all move in a progressive wave) {reject an unexplained reference to nodes and antinodes}

OR
phase difference exists between vibs. Of neighbouring particles in progressive (no phase difference between vibs. Neighbouring particles in standing wave) **[3]**

(b)(i) at least **two** antinodes correctly labelled **AN** B1

at least **two** nodes correctly labelled **N** B1 **[2]**

(ii) correct waves drawn:

4.2.1: sine waves **in phase with B** of maximum amplitude: **top to bottom** B1

4.2.2: **same as graph B** given in fig 4.1 i.e sine wave in phase with B B1

4.2.3: same as graph A given in fig 4.1 i.e. **straight horizontal line** B1

4.2.4: sine wave with same amplitude as B but **180° out of phase** B1

[4]

{try to apply ecf if correct SEQUENCE is shown; judge all graphs generously by eye}

(iii) 2 waves occupy 1.2 m C1
wavelength = **0.6 m** A1 **[2]**

(iv) period = **0.16 s** B **[1]**

(v) frequency = 1/T = 1/0.16 = **6.25 Hz** B1 **[1]**
{allow ecf for cand's value of T}

QUESTION TOTAL = (13)

Paper total = 15 + 17 + 15 +13 = 60