3. Waves

3.1 General properties of waves

Paper 3 and 4

Answer Key

Paper 3

Q1.

Question	Answer	Marks
(a)(i)	reflection	**B1**
(a)(ii)	diffraction	**B1**
(a)(iii)	refraction	**B1**
(a)(iv)	change in speed	**B1**
(b)	(vibrations are) at right angles / perpendicular	**B1**
	(to the) direction of propagation of the wave	**B1**
(c)	tick in 1st and 3rd boxes ☑ radio waves	**B1**
	☐ ☑ light waves	**B1**
(d)	(λ =) 6(.0) (m)	**A3**
	(λ =) 1500 ÷ 250	(C2)
	velocity (of wave) OR wave speed = frequency × wavelength OR (λ =) $v \div f$	(C1)

Q2.

Question	Answer	Marks
(a)	longitudinal	**B1**
(b)(i)	(at least) 3 semi-circular wavefronts after gap showing diffraction	**B1**
	wavefronts with same wavelength as before gap	**B1**
(b)(ii)	one wavelength drawn on diagram	**B1**
(c)	8.3 (Hz)	**A3**
	38 ÷ 4.6	(C2)
	$v = f \times \lambda$ OR (frequency =) speed ÷ wavelength OR (f =) $v \div \lambda$	(C1)

Q3.

Question	Answer	Mark
(a)	(v =) 20 (cm / s)	**A3**
	(v =) 4(.0) × 5(.0)	(C2)
	(v =) $f \times \lambda$	(C1)
(b)	any **three** from: • refraction • direction of waves / wavefronts changes • (due to) change in speed • wavelength changes • as depth of water changes	**B3**

Q4.

Question	Answer	Marks
(a)(i)	(amplitude =) 15 (cm)	**B1**
(a)(ii)	(frequency =) 0.5 (Hz)	**A2**
	(frequency =) number of waves sent out / emitted in one second OR 1 wave in 2.0 (s) OR frequency = 1 ÷ 2(0)	(C1)
(b)	diffraction	**B1**
(c)(i)	refraction	**B1**
(c)(ii)	(change of) wavelength OR (wave) speed OR velocity	**B1**

Q5.

Question	Answer	Marks
(a)	idea of measure more than one wavelength	**B1**
	idea of dividing measurement by number of wavelengths (measured)	**B1**
(b)	(speed =) 24 (cm / s)	**A3**
	(speed =) 6(.0) × 4(.0)	(C2)
	(v =) $f \times \lambda$	(C1)
(c)	(name of effect) refraction	**B1**
	change of speed	**B1**

Q6.

Question	Answer	Marks
(a)(i)	refraction	**B1**
(a)(ii)	wavelength	**M1**
	(of) waves (in shallow water) is shorter / smaller ORA	**A1**
	OR	
	speed	**(M1)**
	(of) waves / wavefronts (in shallow water) is slower ORA	**(A1)**
(b)	2.5 (Hz)	**A3**
	25 / 10	C2
	(frequency =) number of (complete) waves sent out **OR** passing a point in one second / unit time **OR** 1 Hz is 1 wave in one second **OR** no. of waves ÷ time taken	C1
(c)(i)	any electromagnetic wave **OR** an S-wave	**B1**
(c)(ii)	(particle vibrations are) perpendicular / at right angles	**B1**
	to the direction of propagation / wave travel / energy transfer	**B1**

Q7.

Question	Answer	Marks
(a)(i)	S	**B1**
(a)(ii)	Q	**B1**
(b)	transverse	**B1**
(c)	(number of) cycles / vibrations / waves per unit time / second	**B1**

Q8.

Question	Answer	Marks
(a)(i)	8.0 (cm)	**B1**
(a)(ii)	1.5 (cm)	**B1**

Q9.

(b)	horizontal line drawn between 2 peaks OR any 2 adjacent similar points on the wave	**B1**

(d)	longitudinal (vibrations) are parallel to the direction of propagation	**B1**
	transverse (vibrations) are perpendicular/at right angles to the direction of propagation	**B1**

Q10.

Question	Answer	Marks
(a)(i)	R	B1
(a)(ii)	P	B1
(a)(iii)	idea of: number of (complete) waves {sent out or produced or passing a point} {in one second or unit time}	B1

Q11.

Question	Answer	Marks
(a)	movement (of coils / spring) parallel	B1
	to the direction wave / it / disturbance travels	B1
(b)	5.2 (cm)	B1
(c)	number of waves (passing a point OR sent out)	B1
	(in) one second / unit time.	B1
(d)	speed = distance ÷ time	C1
	25 ÷ 0.2(0)	C1
	125 (cm / s)	A1

Paper 4

Q12.

Question	Answer	Marks
(a)(i)	diffraction	**B1**
(a)(ii)	450 Hz	**A2**
	$v = f\lambda$ OR ($f =$) v / λ OR 340 / 0.75	C1
(a)(iii)	large diffraction when gap size / doorway is similar to wavelength	**B1**
	high frequency / 3500 Hz has (much) shorter wavelength **AND** there is less diffraction (with shorter wavelengths)	**B1**
(b)	ray drawn from the violin to point X **AND** from point X to the teacher	**B1**
	mirror drawn at point X and labelled **AND** angle of incidence = angle of reflection	**B1**
	correct arrow on incident ray **OR** correct arrow on reflected ray	**B1**

Q13.

Question	Answer	Marks
(a)	any **two** from: • (longitudinal) vibration / oscillation in wave parallel to propagation direction / direction of travel • transverse wave vibrates / oscillates perpendicular to propagation direction / direction of travel • (longitudinal) consists of compressions and rarefactions • transverse wave consists of crests / peaks and troughs • (longitudinal) needs a medium (to travel)	**B2**
(b)(i)	P-wave **AND** it is longitudinal	**B1**
(b)(ii)	1.8×10^4 m **OR** 18 km	**A2**
	1.5λ **OR** $1.5 \times 1.2 \times 10^4$ **OR** 1.8×10^N	C1
(b)(iii)	$v = f\lambda$ **OR** $v = \lambda / t$ **OR** ($t =$) λ / v **OR** $f = 4600 / 1.2 \times 10^4$ **OR** ($t / 5 =$) $1.2 \times 10^4 / 4600$ **OR** ($t =$) $6(.0) \times 10^4 / 4600$	**M1**
	13 s	**A2**
	$t = 1 / f$ **OR** (time for one wave =) 2.6 (s)	C1

Q14.

Question	Answer	Marks
(a)	P-waves: longitudinal	**B1**
	S-waves: transverse	**B1**
(b)	1600 m **OR** 1.6 km	**A3**
	$v = f\lambda$ **OR** ($\lambda =$) v / f	C1
	($\lambda =$) [7.2×1000] / 4.5 **OR** ($\lambda =$) 1.6×10^N **OR** ($\lambda =$) 7.2 / 4.5	C1

Q15.

(b)	6200–6500 Hz	**A3**
	(λ =) value from 0.051 to 0.053 (m) seen anywhere	**C1**
	(f =) v / λ in any form **or** 330 / 0.052 **or** 330 / 5.2 **or** 63	**C1**
(c)	compressions / rarefactions closer **or** more compressions / rarefactions (in same distance)	**B1**
	less diffraction / spreading out	**B1**
	(because of) smaller wavelength **or** ratio wavelength / gap width smaller	**B1**

Q16.

Question	Answer	Marks
(a)	speed changes **or** (wave) speed is smaller in right-hand part of tank **or** waves slow down **or** bottom (on the page) section of wave hits the boundary first	**C1**
	(wave) speed is smaller in right-hand part of tank **or** waves slow down **or** bottom (on the page) section of wave hits the boundary first	**C1**
	bottom (on the page) / one part / one side / one section of wave slows down first (and different sections are delayed by different amounts)	**A1**
(b)(i)	(f =) $v \div \lambda$ (in any form) **or** 0.39 ÷ 0.052 **or** 0.39 ÷ 0.026 **or** 15 (Hz) **or** 0.39 ÷ 5.2 **or** 0.39 ÷ 2.6 **or** 0.15 (Hz) **or** 0.075 (Hz)	**C1**
	0.39 ÷ 0.052 **or** 15 (Hz) **or** 0.39 ÷ 5.2 **or** 0.15 (Hz) **or** 0.075 (Hz)	**C1**
	7.5 Hz	**A1**
(b)(ii)	angle of incidence / i = 45(°) **or** angle of refraction / r = 33(°)	**C1**
	(v_2 =) $v_1 \times \sin(r) \div \sin(i)$ (in any form) **or** $\lambda_2 = \lambda_1 \times \sin(r) \div \sin(i)$ (in any form) **or** 0.39 × sin(33°) ÷ sin(45°) **or** 0.39 × sin(57°) ÷ sin(45°)	**C1**
	0.30 m / s	**A1**

Q17.

Question	Answer	Marks
(a)(i)	**1** amplitude marked correctly	**B1**
	2 wavelength marked correctly	**B1**
(a)(ii)	trough labelled T	**B1**
(b)	$f = 15 / 60$ (= 0.25)	**B1**
	$v = f\lambda$ in any form OR (v =) $f\lambda$ words, symbols or numbers	**B1**
	(v =) 0.08×0.25 (= 0.02 m / s) OR 0.25×8 (= 2.0 cm / s)	**B1**
	Alternative route 1 : $v = d \div t$ words, symbols or numbers	**(B1)**
	distance moved in one minute = 15×8 OR 120 OR 15×0.08 OR 1.2	**(B1)**
	(v =) $120 / 60$ (= 0.02 m / s) OR $120 \div 60$ OR $15 \times 0.08 \div 60$ OR $1.2 \div 60$	**(B1)**
	Alternative route 2 : time for 1 oscillation = 4 s	**(B1)**
	distance moved in 4 s = 8 cm	**(B1)**
	so speed = $8 \div 4$ = 2 cm / s	**(B1)**
(c)	oscillation at right angles to the direction of propagation / travel / energy transfer (of the wave)	**B1**
	oscillation parallel to / in the direction of propagation / travel / energy transfer (of the wave) OR has compressions and rarefactions OR needs / must have a medium	**B1**

Q18.

Question	Answer	Marks
(a)	(λ =) v / f OR $340 / 20\,000$ OR $340 / 20$	**C1**
	0.017 m AND 17 m	**A1**
(b)	(longitudinal wave) vibration direction parallel to propagation / energy travel direction	**B1**
	transverse wave vibration direction perpendicular to propagation / energy travel direction	**B1**
	consists of rarefactions AND compressions	**B1**

Question	Answer	Marks
(c)	diffraction mentioned	**B1**
	wavelength of sound from drum / low frequency sound greater (than wavelength of high frequency sound)	**B1**
	more diffraction of sound from drum OR less diffraction of high frequency sound	**B1**

Q19.

Question	Answer	Marks
(a)	three wavefronts parallel to each other AND same angles of reflection and incidence both by eye	B1
	two wavelengths same as original wavelength by eye	B1
	three reflected waves meet incident waves at barrier	B1
(b)	$v = f\lambda$ in any form OR $(f =) v/\lambda$	C1
	OR $(f =) 1.2 / 0.36$	C1
	$(f =) 3.3$ Hz	A1

Q20.

Question	Answer	Marks
(a)(i)	At least 3 circular wavefronts centred on gap extending to at least half of semicircle	1
	Same spacing as incident wavefronts	1
(a)(ii)	At least 3 straight, parallel, wavefronts, approximately same length as width of gap	1
	Ends of straight lines curving towards but not reaching barrier	1