Mark scheme

Refraction and total internal reflection

Physics 0625 · Questions from Paper 3 and Paper 4

Total marks

70

MARKS FOR EACH QUESTION

1	2	3	4	5	6	7	8	9	10	Total
5	5	6	7	7	7	7	8	9	9	**70**

Question 1 [5]

1 **(a)** **(i)** refraction
accept refracted ray, ignore bends — B1

(ii) 45 (°) condone no/incorrect unit — B1

(b) **(i)** refracted down at first surface — B1
refracted down at 2nd surface — B1

(ii) X marked above point where candidate's blue light hits screen — B1

[Total: 5]

Question 2 [5]

2 **(a)** *i* correctly shown — B1

(b) **(i)** ray shown in air at angle > 40° — C1
angle same as in Fig. 7.1, by eye — A1

(ii) ray reflected (MO if says along surface) — M1
critical angle exceeded — A1

[Total: 5]

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Question 3 [6]

3(a)(i)	wave / light / energy / ray is completely / entirely reflected (at the boundary between two mediums) **or** no refraction **or** no wave / light / energy / ray passes into second medium / across boundary **or** only reflection occurs	**B1**
3(a)(ii)	light (must pass) from medium where it travels slower **or** to medium where it is faster **or** from medium with larger refractive index **or** to medium with smaller refractive index	**B1**
	angle of incidence (must be) greater than the critical angle / $\sin^{-1}(1 \div n)$	**B1**
3(b)	light / infrared travels in fibre	**B1**
	total internal reflection at inner surface **or** within (graded-index) fibre	**B1**
	light carries information / signal / data / message or signal / light encoded	**B1**

Question 4 [7]

4(a)	sin *i* / sin *r* = n in any form	**C1**
	r = 18°	**A1**
4(b)	light travelling from optically dense medium to optically less dense medium	**B1**
	all light reflected OR no light refracted	**B1**
	angle of incidence is greater than the critical angle	**B1**
4(c)	ray reflected at face AB with *i* = *r* by eye	**B1**
	ray refracted at face BC and bent away from the normal	**B1**

Question 5 [7]

5(a)	any **two** from: • all light is reflected • no light is refracted • (occurs) when light travels in a more dense medium towards a (boundary with a) less dense medium	**B2**
5(b)(i)	(*x* =) 48°	**A3**
	$n = 1 / \sin c$ **OR** $c = \sin^{-1}(1 / n)$ **OR** $\sin c = 1 / 1.5$ **OR** $c = \sin^{-1}(1 / 1.5)$	C1
	$c = 42(°)$	C1
5(b)(ii)	(speed =) 2.0×10^8 m / s	**A2**
	$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in liquid}}$ **OR** $n = \frac{\text{(approx.) speed of light in air}}{\text{speed of light in liquid}}$ **OR** $n = c / v$ **OR** $(v =)\ c / n$ **OR** $1.5 = \frac{3 \times 10^8}{\text{speed of light in liquid}}$	C1

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Question 6 [7]

6 **(a)** (maximum) angle of incidence B1
for a ray to be just refracted / emerge **OR** resulting in an angle of refraction of 90° B1
beyond this angle the ray is totally internally reflected
OR ray travelling from (optically) dense medium to less dense medium B1

(b) ray at A: one emergent ray and one reflected ray B1
refracted away from normal B1
ray at B: one reflected ray only B1
angle of reflection is 50° by eye B1

[Total: 7]

Question 7 [7]

7(a)	(refractive index is) the ratio of the speed of light in two different mediums **OR** (refractive index =) $\frac{\text{speed of light in air}}{\text{speed of light in water}}$ **OR** (refractive index =) $\frac{\text{sine of angle of incidence}}{\text{sine of angle of refraction}}$	**B1**
7(b)	P continues vertical	**B1**
	Q refracted away from normal in the correct direction	**B1**
7(c)	1.3	**A2**
	(n =) 1 ÷ sin 49 **OR** (n =) 1 ÷ sin c	C1
7(d)	any **two** from: • (ray travelling from) dense to less dense medium **OR** water is more dense than air • critical angle = 49° • angle of incidence exceeds critical angle / 49°	**B2**

Question 8 [8]

8(a)	ray travels along the normal **OR** angle of incidence = 0(°)	**B1**
8(b)(i)	n = 1 / sin c **OR** (n =) 1 / sin c **OR** (n =) 1 / sin 42 (°)	**M1**
	1.5	**A1**
8(b)(ii)	ray reflected at BC **AND** no refracted ray	**M1**
	ray hits AC with angle of incidence = 0 °	**A1**
	correct refraction of candidate's ray into air at AC	**B1**

8(c)	any **two** from: • high rates (of data transmission) / fast (data transmission) • carry large amounts (of data / information) • secure • little signal / data loss • glass is transparent to (some) infrared	**B2**

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Question 9 [9]

9(a)(i)	i = 60° used or seen	**C1**
	sin i / sin r = n in any form	**C1**
	ray refracted toward normal and toward AC	**C1**
	ray clearly refracted down in prism reaching AC with r = 35(°)	**A1**
9(a)(ii)	10°	**B1**
9(b)	refracted away from normal	**B1**
9(c)(i)	(total internal) reflection at X NOT refraction at X or anywhere else	**B1**
	reaches end of fibre with only one additional reflection (off lower internal edge of fibre)	**B1**
9(c)(ii)	total internal reflection	**B1**

Question 10 [9]

10(a)(i)	any **two** correct = 1 mark all **three** correct = 2 marks • speed decreases / gets less / slower • wavelength decreases / gets smaller / shorter • frequency unchanged / stays the same / no effect	**B2**
10(a)(ii)	(n =) sin 45 / sin 30	**B1**
10(a)(iii)	46° ***OR*** 45°	**A1**
	n = 1 / sin c ***OR*** (c =) $\sin^{-1}$ (1 / n) ***OR*** (c =) $\sin^{-1}$ (1 / 1.4) ***OR*** sin c = 1 / n	**M1**
10(b)(i)	total internal reflection ***AND*** i = r for initial reflection	**B1**
	ray reaches end of fibre after a total of 2 or 3 reflections only	**B1**
10(b)(ii)	any **two** from: • internet transmission / (highspeed) broadband • telephone networks • cable TV } ***OR*** telecommunications • endoscope • lasers in surgery • microscopy • military aircraft wiring • imaging (cameras) in industry • inspection of pipes or other hard to reach places	**B2**

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