

- 1 (a) (condone discontinuities at boundaries)
- mirror:**
 equally spaced reflected waves, approx. same spacing as incident (by eye) B1
 IGNORE reflected waves to left of arrowhead
 correct angle to surface, by eye B1
- block:**
 reduced wavelength in block B1
 ACCEPT refracted waves to left of arrowhead
 at sensible angle of refraction B1
 CONDONE reflected waves shown as well as refracted
- (b) (i) $3 \times 10^8 / \text{speed in glass} = 1.5$ C1
 $2 \times 10^8 \text{ m/s}$ A1
- (ii) $\sin 70^\circ / \sin r = 1.5$ C1
 38.7895° to 2 or more sig figs A1
- [8]
- 2 (a) two correct rays $\pm 1 \text{ mm}$ on axis ignore any arrows B1
 I drawn between candidate's intersection and axis B1
- (b) (i) (becomes) larger B1
 further from lens B1
- (ii) (becomes) virtual)
 (becomes) (even) larger) any 2 B1 + B1
 (becomes) upright)
 situated to right of lens (IGNORE further away))
- [6]

- 3 (a) light of one colour/frequency/wavelength B1
- (b) $n = \sin r / \sin i$ OR $n = \sin i / \sin r$ in any form C1
 $\sin r / \sin 30 = 1.49$ OR $\sin r = 1.49 \times \sin 30$ C1
 $48.0^\circ - 48.2^\circ$ A1
- (c) ray at angle $>30^\circ$ and $<60^\circ$ to normal, by eye, correct way **NO** e.c.f. B1
 Ignore any angles or labelling
- (d) colours/spectrum would appear OR range of angles (ignore "rainbow") B1
 OR dispersion OR ray splits up
- (e) 90° approx (accept any value 80° to 90°) B1
- (f) (totally internally) reflected OR T.I.R. B1 [8]
-
- 4 (a) (i) light of one colour/frequency/wavelength B1
- (ii) $n = \sin r / \sin i$ OR $n = \sin i / \sin r$ in any form C1
 $1.33 = \sin r / \sin 40$ OR $\sin r = 1.33 \times \sin 40$ C1
 Any value between $58.68^\circ - 60^\circ$ inclusive A1
- (iii) ray correct, by eye, bent away from normal B1
 ignore any arrows or labelling **NO** ecf
- (b) (i) reflected (at B) or T.I.R. NOT deflects/refracts M1
angle of incidence bigger than critical angle
 or 50° is bigger than 48.8° /C.A. A1
- (ii) ray correct, by eye, with no refracted part B1 [8]

- 5 (a) (i) refracted ray, angle $< i$, emergent ray approx parallel to incident B1
- (ii) reflected ray at equal angle to incident, by eye B1 [2]
- (b) (i) $88-90^\circ$ B1 [1]
- (ii) 43° c.a.o. B1 [1]
- (iii) $n = \sin(\text{his}90^\circ)/\sin(\text{his}43^\circ)$ C1
- 1.466 or 1.47 or 1.5 c.a.o. any no s.f. ≥ 2 A1 [2]
- (c) n or his 1.5 = speed in air/speed in glass e.c.f. C1
- speed in glass = $2(.0) \times 10^8$ m/s e.c.f. any no s.f. ≥ 2 A1 [2]
- [Total: 8]**