P208 Q1-2 Markscheme (not 1 b ii)

1 (a) (i) $1.52 \sin c = 1.35 \sin 90$ gives — **1**
$\sin c = 0.888$. — **1**
Hence $c = 62.6°$ — **1**

Tests the ability to calculate the critical angle for a boundary between two transparent substances, given the refractive index of each and then to apply that to sketch the path of a light ray in an optical fibre.

(ii) light ray confined to core, angle of incidence > 62.6°, more that one total internal reflection shown in Figure EA 13.1.1 below. — **1** **1** **1**

(b) (i) Total internal reflection takes place at the core-cladding boundary so the light rays stay in the core. If two fibres are in contact, light cannot pass from one fibre to the other because it is confined to the core of each fibre. — **1** **1** **1**
Without cladding, the cores would be in contact and light could pass from one fibre to another where they are in contact. — **1**
Light signals in each fibre would therefore not be secure.

Knowledge of total internal reflection and critical angle needs to be applied to explain why cladding of optical fibres is necessary. A general statement about the need to make prevent light crossing over where fibres are in contact for security purposes should be backed up by relevant physics points about why cladding fulfils this function.

2 (a) *Ray drawn to show*: — **3**
- total internal reflection at right hand interior face of glass block
- ray emerging from base of block into the air
- refracted away from normal

Use a ruler and draw in the normals at the points where the ray meets a boundary. You are told that the critical angle of the glass is 45°; therefore the ray incident at 50° must experience total internal reflection down to the base of the block. At this point it will emerge into the air (because the angle of incidence is only 40°), bending away from the normal as it does so.

(b) use of $\sin \theta_C = \frac{n_2}{n_1}$ — **1**

gives $n_1 = \frac{1.00}{\sin 45°} = 1.41$ — **1**

For the critical condition to occur, the light must be travelling from a more dense medium (refractive index n_1) to a less dense medium (refractive index n_2). In this case, from glass to air. You are asked **to show** that the value is 1.41, making it even more important to write down the steps in your working.

(c) use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ — **1**
gives $1.00 \sin \theta = 1.41 \sin 40°$ — **1**
$\therefore$ angle of incidence $\theta = 65.0°$ — **1**

The angle of refraction (within the glass at the top surface) is 40° because the angle between the refracted ray and the top surface is 50° (alternate angles).