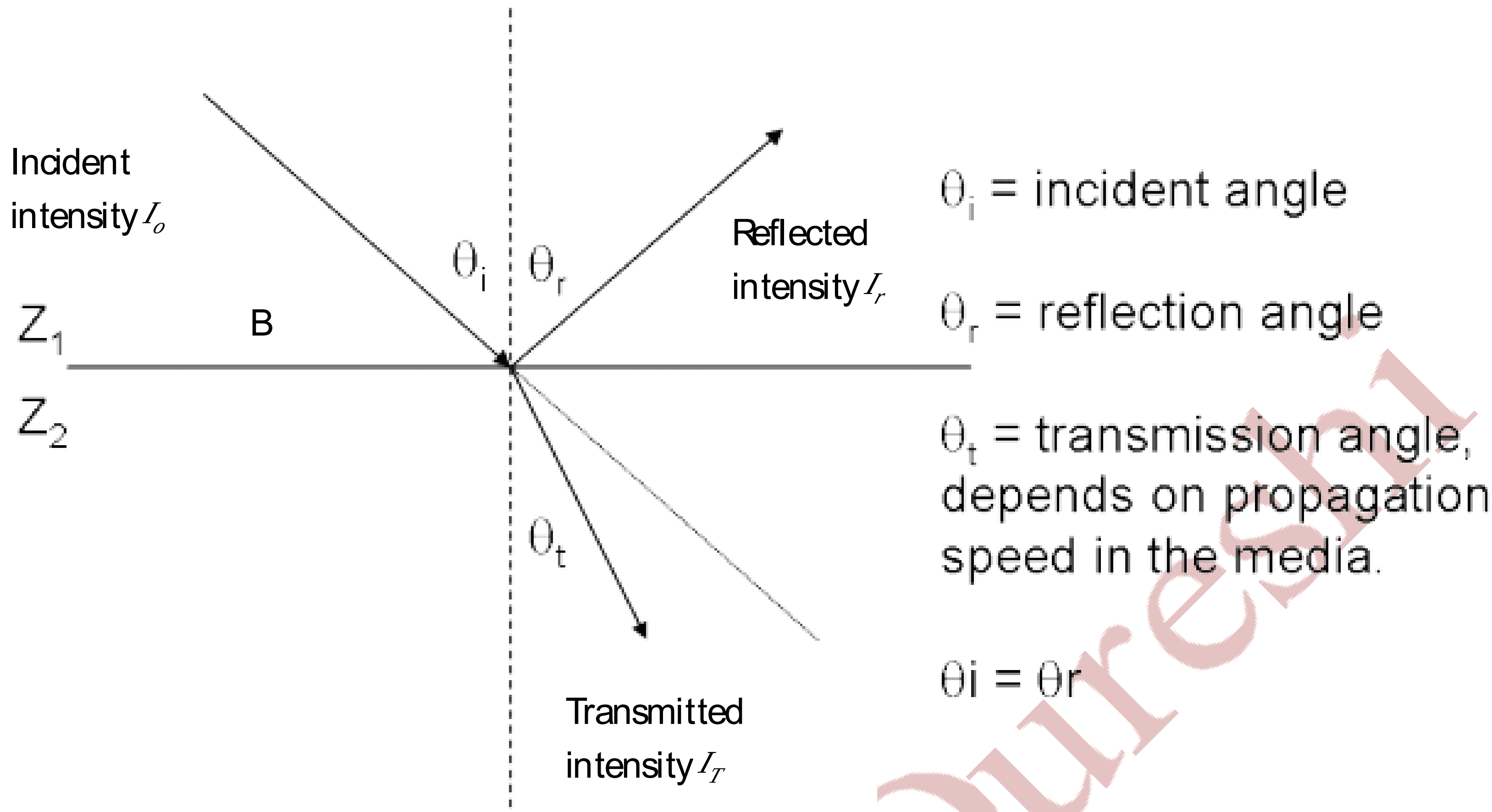

If you want to calculate intensity reflection coefficient at the boundary B then use

$$\propto = \frac{I_r}{I_o} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

This shows how much intensity is reflected out of received at the boundary B.

We also know one more thing; that when ultrasound passes through certain medium, some of its intensity is absorbed and the rest is transmitted to next layer. Now if you want to calculate the transmitted intensity bet the boundary B then use following

$$I_T = I_o e^{-kx}$$

Now k is the absorption coefficient of layer 1 and x is the thickness of layer 1. If you use the values of k and x, you can get the ration of transmitted and incident intensity which is called intensity absorption coefficient given below

$$\beta = \frac{I_T}{I_o}$$

So now we are able to figure out how much intensity is received in the start at boundary B and how much is reflected back.

Consider the following diagram

Material	Speed of sound / ms^{-1}	Density / kgm^{-3}	Acoustic impedance / $kg\ m^{-2}\ s^{-1}$
Air	330	1.3	430
Bone	2800	1.5×10^{3}	
Tissue	1600	1.0×10^{3}	1.6×10^{6}

Calculate the acoustic impedance of bone and enter your answer in the table above.

(c) Ultrasound of intensity I_0 is traveling in a medium of impedance Z_1 and is incident on a medium of impedance Z_2. The **reflected** ultrasound has intensity I_R given by

$$I_R = I_0\left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2$$

(i) With reference to the equation above explain why ultrasound would not be an effective method for a brain scan.

(ii) Using data from the table in (b) determine the ratio $\frac{I_R}{I_0}$ of ultrasound entering tissue from air.

(iii) Using your answer to (c)(ii), explain the purpose of the gel that is applied to the skin before an ultrasound scan.

3. (a) Explain the main principles behind the use of ultrasound to obtain diagnostic information about internal body structures.
(b) State and explain one advantage of the use of high frequency ultrasound as compared with low frequency ultrasound for medical diagnosis.

(c) The absorption (attenuation) coefficient for ultrasound in muscle is 23 m^{-1}.
A parallel beam of ultrasound is passed through a muscle of thickness 6.4 cm.

(i) Calculate the ratio

$$\frac{\text{intensity of transmitted beam}}{\text{intensity of incident beam}}.$$

(ii) An ultrasound transmitter emits a pulse. Suggest why, when the signal from the pulse is processed, any signal received later at the detector is usually amplified more than that received at an earlier time.

[Nov 13/ Paper 4/ CIE]