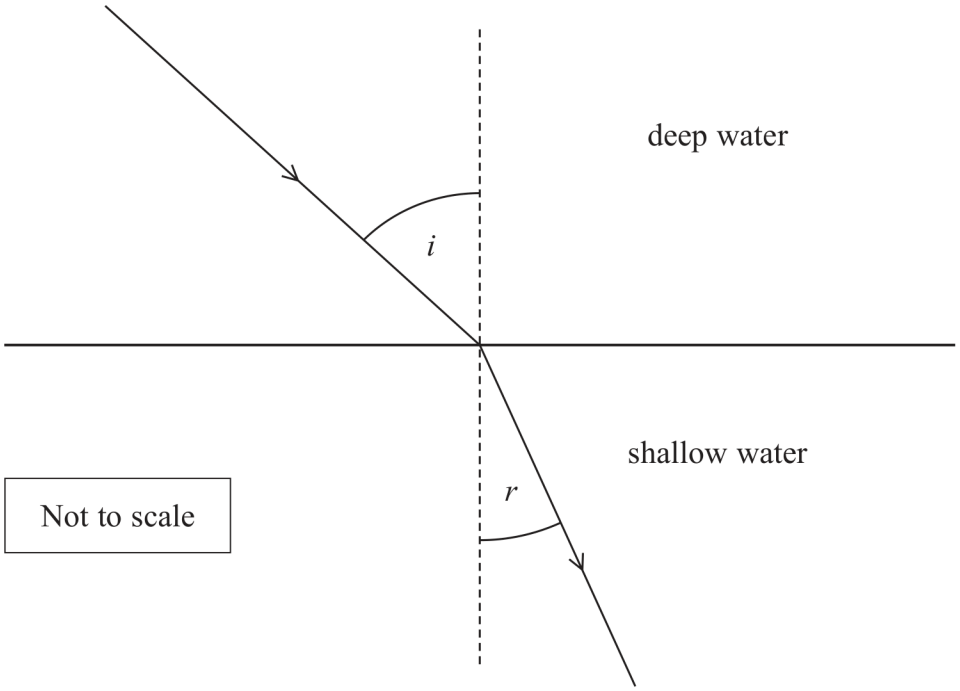
**15** A water wave approaches a boundary between deep water and shallow water and is refracted. The diagram shows how the direction of travel of the wave changes.




(a) Explain why the wave is refracted as shown, as it travels from deep water into shallow water. You may add to the diagram.

**(2)**

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(b) When waves travel across the surface of water, their speed $v$ is dependent on the depth $d$ of the water and the wavelength $\lambda$ of the waves.

For waves travelling in deep water, where $d > \frac{\lambda}{2}$, $v = \sqrt{\frac{g\lambda}{2\pi}}$

For waves travelling in shallow water, $v = \sqrt{(gd)}$

(i) Calculate the angle of refraction $r$.

wavelength of waves in deep water = 15 m
depth of deep water = 10 m
depth of shallow water = 0.50 m
angle of incidence = 40°

**(5)**

$r$ = .....

(ii) In 1933, the crew of the US Navy ship USS Rampo took measurements from one of the largest waves ever recorded. The wavelength of the wave was 342 m and the time period was 14.8 s.

Show that the depth of the water where the crew measured the wave was greater than 170 m.

**(3)**

**(Total for Question 15 = 10 marks)**