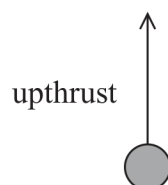18 A spherical polystyrene bead is immersed in oil. The bead has diameter 4.00×10^{-3} m. The bead is released and moves upwards through the oil at a constant velocity.

(a) Complete the free body force diagram below to show all the forces acting on the polystyrene bead.

(2)

upthrust $\uparrow$

(b) Show that the upthrust the oil exerts on the bead is about 3.1×10^{-4} N.

density of oil = $930 \, \text{kg} \, \text{m}^{-3}$

(3)

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(c) Stokes' law shows how the viscous drag on a sphere is related to its velocity through a fluid.

Stokes' law is only valid if the bead is moving sufficiently slowly through the oil.

(i) State the reason for this condition.

(1)

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....

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(ii) For Stokes' law to be valid the speed of the bead through the oil must be less than v_R, where

$$v_R = \frac{10 \times \text{viscosity of oil}}{\text{density of oil} \times \text{diameter of the bead}}$$

Deduce whether Stokes' law can be applied to this bead.

viscosity of oil $= 4.90 \times 10^{-2}\,\text{Pa s}$
weight of polystyrene bead $= 1.05 \times 10^{-5}\,\text{N}$

(5)