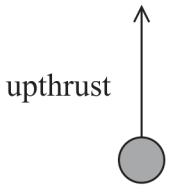
18 A spherical polystyrene bead is immersed in oil. The bead has diameter 4.00×10^{-3} m. The bead is released and moves upwards through the oil at a constant velocity.

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

(2)



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

density of oil = 930 kg 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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(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 = 4.90×10^{-2} Pa s
weight of polystyrene bead = 1.05×10^{-5} N

(5)

(Total for Question 18 = 11 marks)