2 A water jetpack consists of a backpack consisting of a motor, two thrusters and a pipe for constant supply of water. A diagram of one thruster is shown in Fig. 2.1.

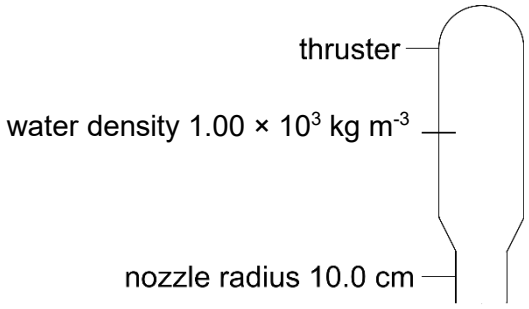

Fig. 2.1

Water is ejected vertically downwards through the nozzle. The thruster moves vertically upwards. The density of water is 1.00×10^3 kg m^{-3}. The nozzle has a circular cross-section of radius 10.0 cm. The thruster ejects 30.0 kg of water in 0.20 s. Assume that the water leaving the nozzle has the shape of a cylinder of radius 10.0 cm.

(a) (i) Show that the water has a constant speed of 4.8 m s^{-1} relative to the thruster. [2]

(ii) Show that the force exerted on water ejected by the jetpack is 1.4×10^3 N. [1]

(iii) Determine the maximum combined mass of a jetpack with its user that can be lifted with an acceleration of 9.81 m s^{-2}. Explain your answer.

mass = ... kg [3]

(b) When in use, the jetpack takes in a constant volume of water from the environment and has a constant mass. To move horizontally, the user tilts the thrusters slightly using the handles connected. Fig. 2.2 shows one such jetpack in use above a lake.

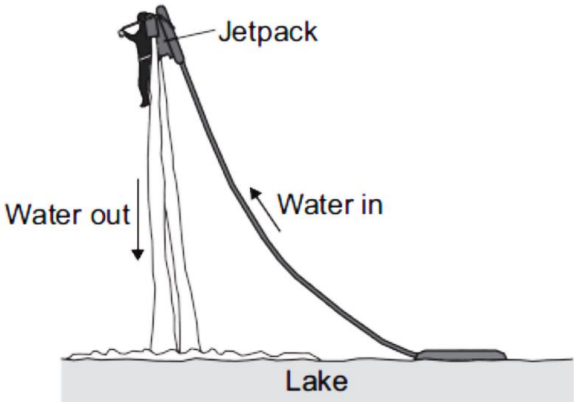

Fig. 2.2

(i) Determine, for a user with a jetpack of combine mass 80 kg, the maximum angle with respect to the vertical which the thrusters can be tilted without the user losing altitude. Assume that the force exerted by the water pipe on the user is negligible.

maximum angle = ... ° [2]

(ii) Calculate the power delivered to the water for a stationary user just above the water.

power delivered = ... W [2]

[Total: 10]