Answer **all** the questions in the spaces provided.

1 **(a)** Two point masses are separated by a distance x in a vacuum.
State an expression for the force F between the two masses M and m.
State the name of any other symbol used.

.....

.....

.....[1]

(b) A small sphere S is attached to one end of a rod, as shown in Fig. 1.1.

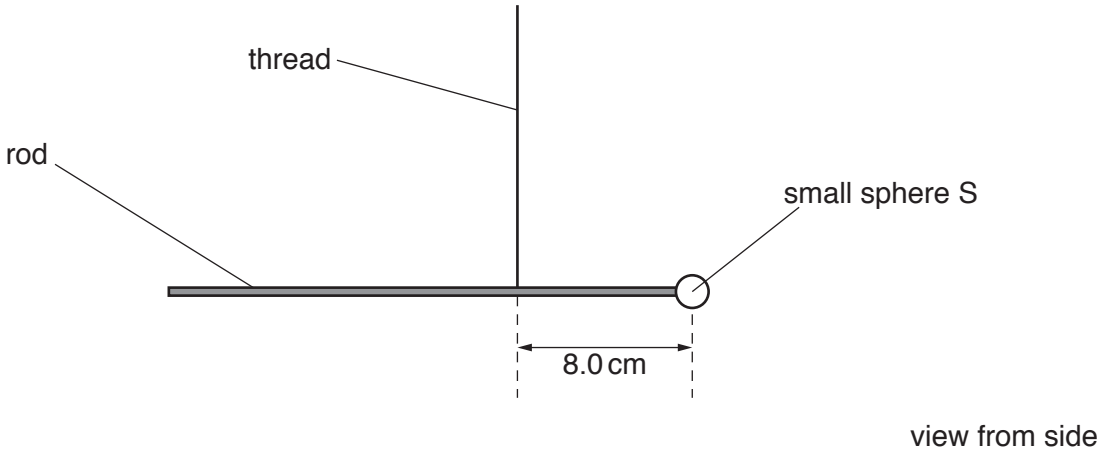

Fig. 1.1 (not to scale)

The rod hangs from a vertical thread and is horizontal.
The distance from the centre of sphere S to the thread is 8.0 cm.

A large sphere L is placed near to sphere S, as shown in Fig. 1.2.

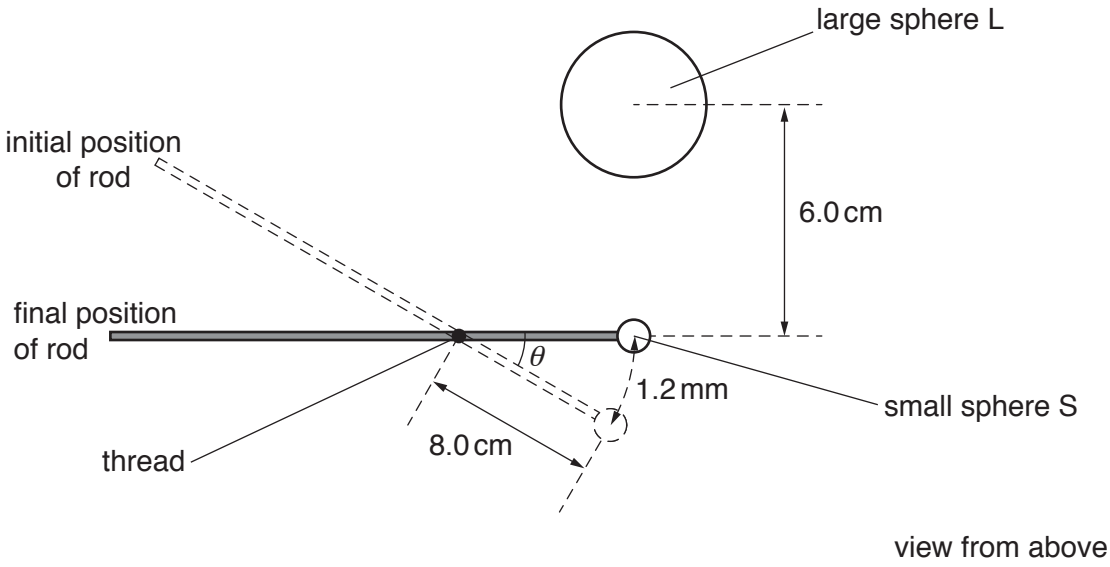

Fig. 1.2 (not to scale)

There is a force of attraction between spheres S and L, causing sphere S to move through a distance of 1.2 mm.
The line joining the centres of S and L is normal to the rod.

(i) Show that the angle θ through which the rod rotates is 1.5×10^{-2} rad.

[1]

(ii) The rotation of the rod causes the thread to twist.
The torque T (in N m) required to twist the thread through an angle β (in rad) is given by

$$T = 9.3 \times 10^{-10} \times \beta.$$

Calculate the torque in the thread when sphere L is positioned as shown in Fig. 1.2.

torque = ... N m [1]

(c) The distance between the centres of spheres S and L is 6.0 cm.
The mass of sphere S is 7.5 g and the mass of sphere L is 1.3 kg.

(i) By equating the torque in **(b)(ii)** to the moment about the thread produced by gravitational attraction between the spheres, calculate a value for the gravitational constant.

gravitational constant = ... $N m^2 kg^{-2}$ [3]

[Turn over

(ii) Suggest why the total force between the spheres may not be equal to the force calculated using Newton's law of gravitation.

.....

.....[1]

[Total: 7]