2 A spacecraft in deep space uses jets of hot gas from its thrusters to change its velocity. Fig. 2.1 shows a side view of the spacecraft and some of its thrusters.

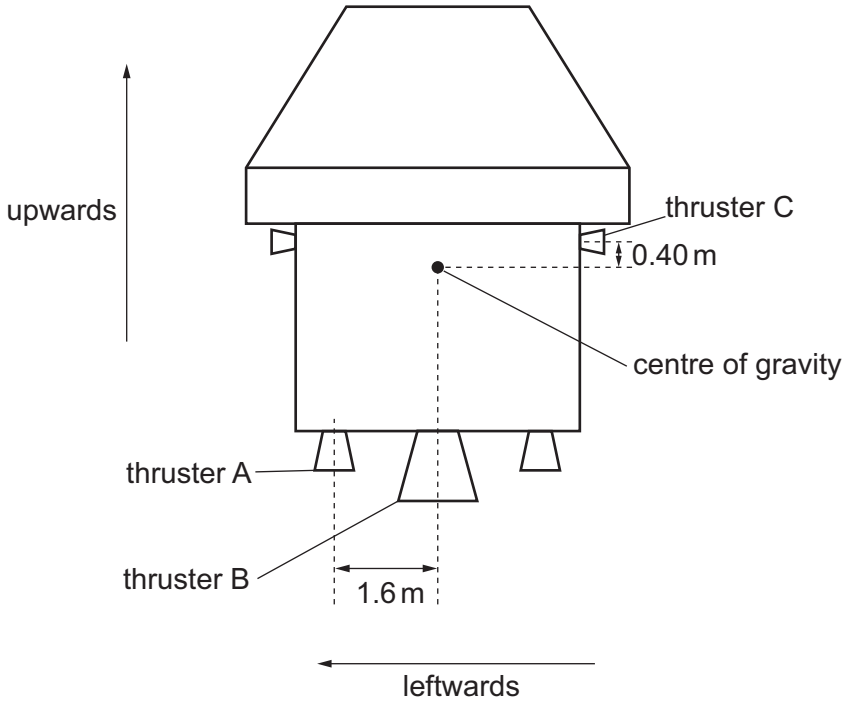

Fig. 2.1 (not to scale)

Thruster A is a distance of 1.6 m leftwards from the centre of gravity of the spacecraft. Thruster C is a distance of 0.40 m upwards from the centre of gravity of the spacecraft.

Thrusters A and B can produce forces on the spacecraft in the upwards direction only.
Thruster C can produce a force on the spacecraft in the leftwards direction only.
All the thrusters shown produce forces entirely in the same plane as the centre of gravity.

(a) (i) Thruster A is activated, producing a force of 60 N upwards on the spacecraft. Thruster C is also activated, producing a force of 220 N in the leftwards direction on the spacecraft.

Calculate the resultant moment due to these forces about the centre of gravity.

resultant moment = ... N m [2]

(ii) State and explain whether the forces from A and C are a couple.

.....

.....

..... [1]

(b) Thrusters A and C are now switched off and the spacecraft is stationary. Thruster B is activated at time t_1, producing a constant force on the spacecraft until the fuel runs out at time t_2. As the fuel is used, the total mass of the spacecraft decreases.

On Fig. 2.2, sketch the variation of speed of the spacecraft with time from t_1 to t_2.

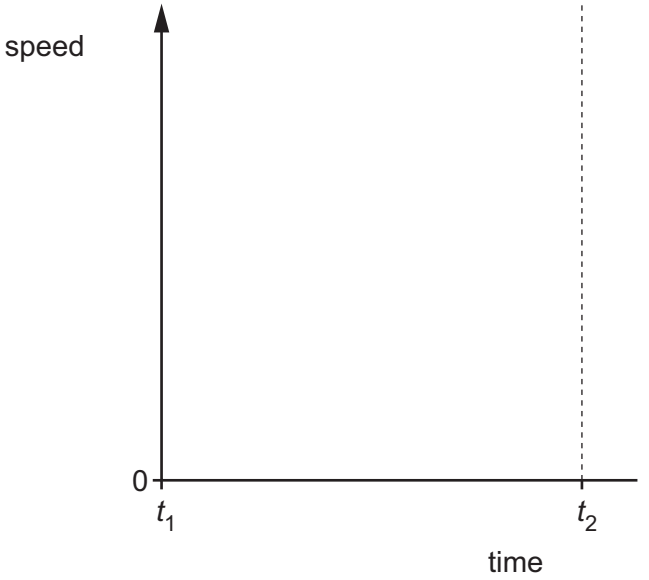

Fig. 2.2

[2]

(c) The spacecraft now splits apart into a carrier and a payload as shown in Fig. 2.3.

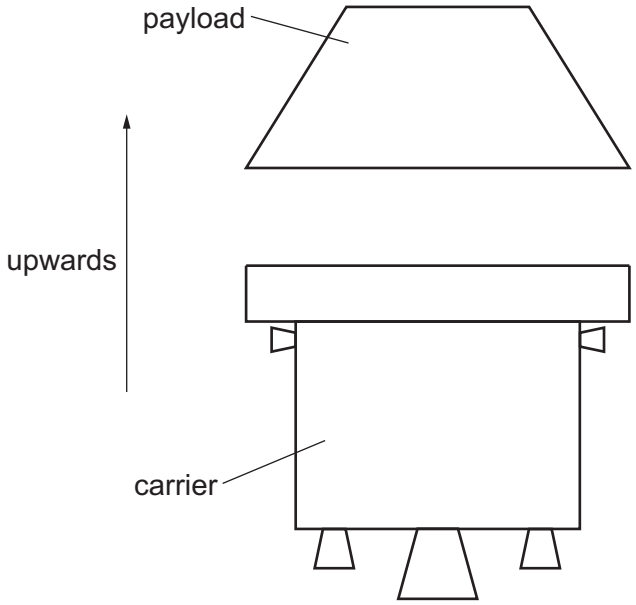

Fig. 2.3

During the split, an average force of 5500 N acts on the payload for a time of 0.36 s. The velocity of the payload increases by 8.5 m s^{-1} in the upwards direction.

The combined mass of the carrier and payload is 2.5×10^3 kg.

(i) State the principle of conservation of momentum.

.....

.....

..... [2]

(ii) Show that the mass of the payload is 230 kg.

[2]

(iii) Calculate the magnitude of the change in velocity of the carrier.

change in velocity = ... $m\,s^{-1}$ [3]

[Total: 12]