15 Some asteroids pass very close to the Earth. Scientists are planning methods to deflect asteroids, to prevent them hitting the Earth.

One method would involve colliding a spacecraft into the surface of the asteroid, to change the path and speed of the asteroid. The spacecraft would remain joined to the asteroid after the collision.

(a) This collision method is modelled for a spacecraft travelling in a direction at 90° to the path of the asteroid.

Sketch a labelled vector diagram to show the momenta of the bodies before and after the collision.

(2)

(b) Show that the momentum of the spacecraft is about 10^7 N s.

mass of spacecraft = 920 kg
speed of spacecraft = 12 000 m s^{-1}

(2)

.....

.....

.....

.....

(c) Show that this collision method causes the asteroid to change its direction through an angle of about 10^{-7} radian.

momentum of asteroid = 7.6×10^{13} N s

(2)

.....

.....

.....

.....

(d) After the collision, the asteroid and spacecraft remain joined and move together.

Calculate the component of their velocity at 90° to the original path of the asteroid after the collision.

mass of asteroid = 2.8×10^9 kg

(2)

Component of velocity = ...

(e) Another method would involve attaching a rocket motor to the asteroid and using the motor to apply a force to the asteroid.

In this method the force is applied at 90° to the path of the asteroid.

Deduce whether this would produce a change in momentum as great as the change produced by the collision method.

force exerted by rocket motor = 5.1×10^6 N
time for which rocket motor applies force = 6 minutes

(2)

(Total for Question 15 = 10 marks)