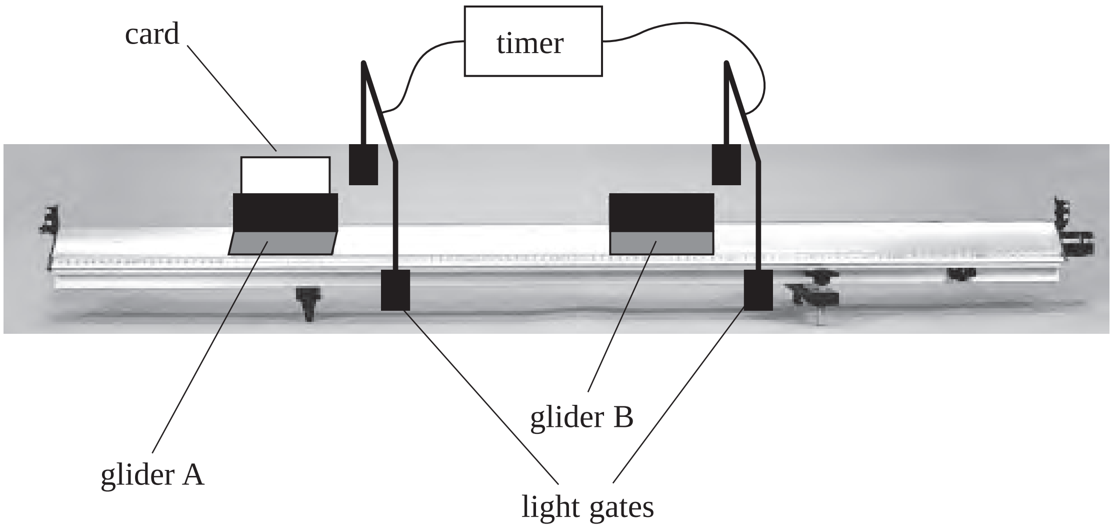
1 The law of conservation of momentum can be investigated using a low-friction track with two gliders. Glider B is stationary. Glider A is given a gentle push towards glider B. The gliders collide, stick together and move off.



(a)*(i) Describe how you would use the apparatus shown to verify the law of conservation of momentum.

(5)

(ii) Explain why it is necessary to use a low-friction track to verify the law of conservation of momentum.

(2)

(b) In a different investigation a glider of mass 0.50 kg travelling at 0.90 m s^{-1} collides head-on with a stationary glider of mass 0.70 kg. The 0.50 kg glider continues moving in the same direction at a velocity of 0.20 m s^{-1}. The gliders do not stick together.

(i) Calculate the velocity of the 0.70 kg glider after the collision.

(2)

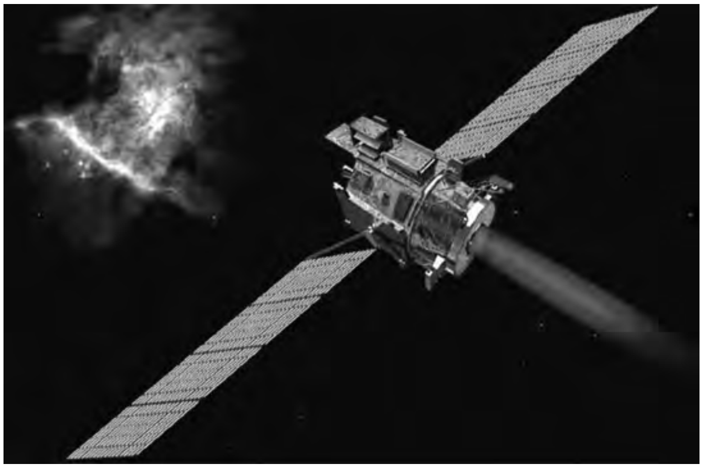
Velocity =

(ii) By doing further calculations, determine whether the collision is elastic.

(2)

(Total for Question = 11 marks)

***2** The photograph shows a probe moving in space.



Whilst moving, empty fuel tanks can be ejected by means of an explosion. This has the effect of increasing the speed of the probe.

Discuss whether conservation of momentum and conservation of energy apply in this situation and why the speed of the probe increases.

(6)

(Total for Question = 6 marks)

***3** A stationary radium nucleus decays by emitting an alpha particle. The speed of the recoiling nucleus is small compared to the speed of the alpha particle.

Explain why the nucleus recoils and why its speed is small compared to that of the alpha particle.

(4)

(Total for Question = 4 marks)

4 An electron is accelerated from rest through a potential difference of 700 V in a vacuum.

(a) Show that the final momentum of the electron is about 1×10^{-23} N s.

(3)

(b) Calculate the wavelength associated with this electron.

(2)

Wavelength =

(c) Suggest why such electrons would be useful for investigating the atomic structure of materials.

(1)

(Total for Question = 6 marks)

5 (a) Explain what is meant by the principle of conservation of momentum.

(2)

(b) The picture shows a toy car initially at rest with a piece of modelling clay attached to it.

A student carries out an experiment to find the speed of a pellet fired from an air rifle. The pellet is fired horizontally into the modelling clay. The pellet remains in the modelling clay as the car moves forward. The motion of the car is filmed for analysis.

The car travels a distance of 69 cm before coming to rest after a time of 1.3 s.

(i) Show that the speed of the car immediately after being struck by the pellet was about 1 m s^{-1}.

(2)

(ii) State an assumption you made in order to apply the equation you used.

(1)

(iii) Show that the speed of the pellet just before it collides with the car is about 120 m s^{-1}

mass of car and modelling clay = 97.31g
mass of pellet = 0.84 g

(3)

(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

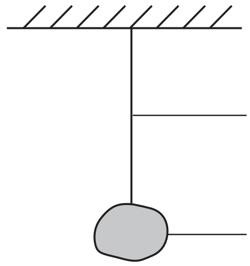
(3)

(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.

Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



The student's data and calculations are shown:

Data
mass of pellet = 0.84 g
mass of pendulum and pellet = 71.6 g
change in vertical height of pendulum = 22.6 cm

Calculations
change in gravitational potential energy of pendulum and pellet
$= 71.6 \times 10^{-3}\,\text{kg} \times 9.81\,\text{N kg}^{-1} \times 0.226\,\text{m} = 0.16\,\text{J}$
therefore kinetic energy of pendulum and pellet immediately after collision = 0.16 J
therefore kinetic energy of pellet immediately before collision = 0.16 J
therefore speed of pellet before collision = 19.5 m s^{-1}

There are no mathematical errors but her answer for the speed is too small.

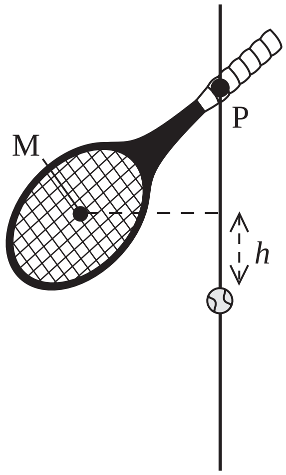
State and explain which of the statements in the calculations are correct and which are not.

(4)

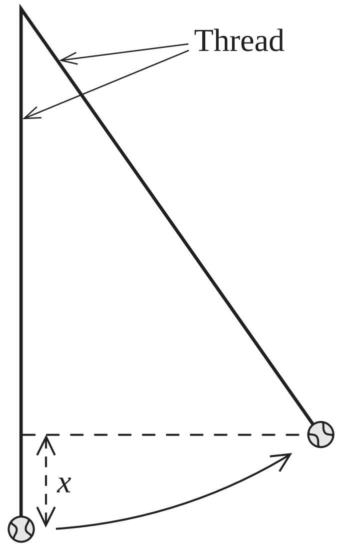
(Total for Question = 16 marks)

6 A student is carrying out an investigation into collisions between a bat and a ball.

The bat is pivoted at a point P so that it can swing freely. The centre of mass M of the bat swings through an arc and hits the ball. M moves through a height h as shown below.



The ball is suspended vertically by a thread. The bat hits the ball which swings to a maximum height x.



One set of measurements is $h = 0.030$ m $x = 0.10$ m

(a) Show that the speed of M just before the collision is about 0.8 m s^{-1}.

(2)

(b) The student calculates the speed of the ball just after the collision to be 1.4 m s^{-1} .
The mass of the bat is 320 g and the ball is 55 g.

Calculate the speed of the bat just after the collision and state one assumption you make.

(4)

Speed of bat =

Assumption:

(c) Determine whether the collision was elastic or inelastic.

(3)

(d) Discuss your conclusion with reference to possible uncertainties in the measurements of *x*.

(2)

(Total for Question = 11 marks)

***7** How tiny bacteria move is of interest in nanotechnology. Mycobacteria move by ejecting slime from nozzles in their bodies.

Explain the physics principles behind this form of propulsion.

(4)

(Total for Question = 4 marks)