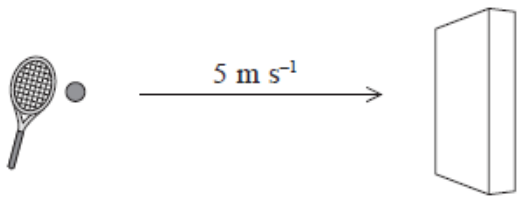
Questions

Q1.

A tennis ball of mass 0.06kg moves towards a wall at a velocity of 5 m s^{-1} as shown.



The tennis ball hits the wall perpendicularly and rebounds at the same speed.

What is the change in momentum of the ball?

(1)

☒ **A** 0.60kg m s^{-1}

☒ **B** 0.30kg m s^{-1}

☒ **C** −0.30kg m s^{-1}

☒ **D** −0.60kg m s^{-1}

(Total for question = 1 mark)

Q2.

Which of the following is a possible unit for rate of change of momentum?

☒ **A** kg m s^{-2}

☒ **B** kg m s^{-1}

☒ **C** N s^{-1}

☒ **D** N s

(Total for question = 1 mark)

Q3.

A particle of mass m, has a velocity v and momentum p.

Which of the following is correct for this particle?

☒ **A** $mv^2/2 = p^2$

☒ **B** $m^2v^2/2 = p^2$

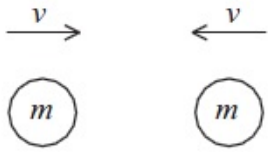
☒ **C** $m^2v^2 = p^2/m$

☒ **D** $mv^2 = p^2/m$

(Total for question = 1 mark)

Q4.

Two identical spheres of mass m are both travelling with a speed v towards each other.



The spheres collide head-on.

Which of the following statements **must** be true after the collision?

☒ **A** total momentum = $2mv$

☒ **B** total momentum = 0

☒ **C** total kinetic energy = mv^2

☒ **D** total kinetic energy = 0

(Total for question = 1 mark)

Q5.

A trolley, mass 0.50 kg, has a speed of 2.0 m s^{-1}. A second trolley, mass 1.0 kg, has a speed of 2.0 m s^{-1}. The two trolleys are travelling in opposite directions and collide.

Which of the following could be a correct value of total momentum, in kg m s^{-1}, after the collision?

(1)

☒ **A** 0

☒ **B** 1.0

☒ **C** 2.0

☒ **D** 3.0

(Total for question = 1 mark)

Q6.

Two objects of mass *m* travel towards each other on a smooth horizontal surface, each with velocity of magnitude *v*. The collision is elastic.

After the collision the

☒ **A** total kinetic energy is $2mv^2$

☒ **B** total kinetic energy is mv^2

☒ **C** total momentum is $2mv$

☒ **D** total momentum is mv

(Total for question = 1 mark)

Q7.

A space rocket lifts off vertically.

The rocket lifts off because

☒ **A** the exhaust gases exert a force on the ground.

☒ **B** the exhaust gases exert a force on the rocket.

☒ **C** the ground exerts a force on the rocket.

☒ **D** the rocket exerts a force on the ground.

(Total for question = 1 mark)

Q8.

A body, initially at rest, explodes into two masses M_1 and M_2. These masses move apart with speeds v_1 and v_2 respectively.

The ratio v_1/v_2 is equal to

A $\frac{M_1}{M_2}$

B $\frac{M_2}{M_1}$

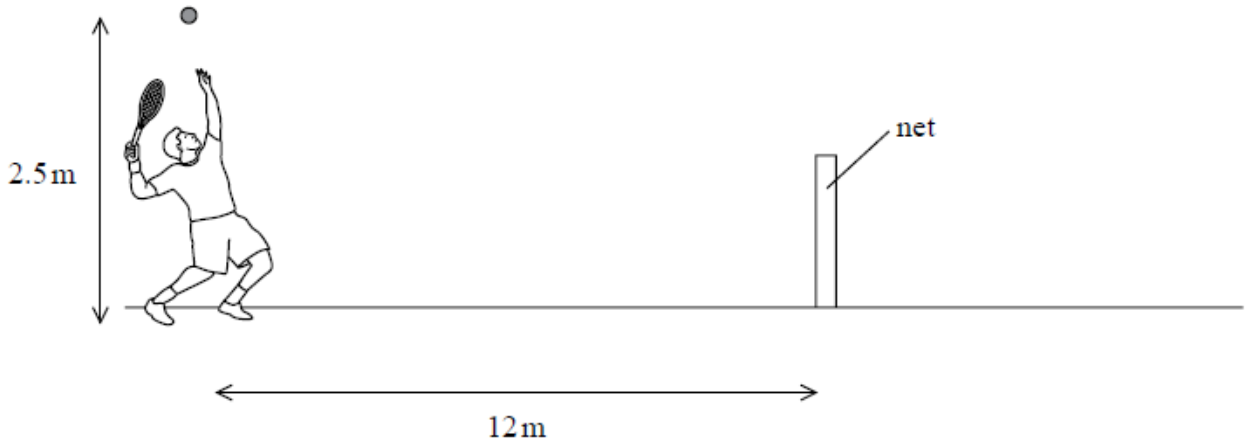
C $\frac{\sqrt{M_1}}{\sqrt{M_2}}$

D $\frac{\sqrt{M_2}}{\sqrt{M_1}}$

(Total for question = 1 mark)

Q9.

A tennis player uses a racket to hit a ball over a net.



The player stands 12 m from the net. He throws the ball vertically upwards and hits the ball at a height of 2.5 m above the ground. The ball leaves the racket **horizontally** with a velocity of 25 m s^{-1}. The ball has a mass of 0.06 kg.

The ball is in contact with the racket for 0.04 s.

Calculate the average force on the ball.

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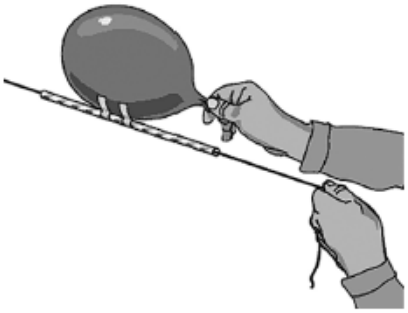
Average force = ...

(Total for question = 3 marks)

Q10.

A length of string is threaded through a drinking straw. The string is fixed at one end and held at the other so that it is at 30° to the horizontal. A balloon is inflated and attached to the straw. When the balloon is released, the air escapes from the balloon and the balloon and straw start to move up the string.



With reference to Newton's laws of motion, explain why the balloon starts to move.

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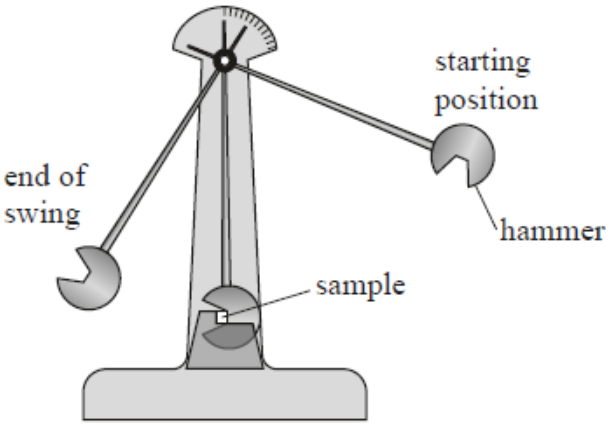
Q11.

Read the passage and answer the questions below.



(ref: Physics Review April 2015 p22)

The Charpy test is used by scientists to measure the fracture toughness of a material. A simple pendulum, with a hammer on the end, is held high and released so that it swings down and strikes the sample. The height from which the hammer is released is increased until the sample fractures. Some energy is absorbed by the sample in the impact but the hammer continues to move until it comes to rest at the top of its swing. Due to the law of conservation of energy the hammer will not swing up as high as its starting position. The difference in height between the start and end is proportional to the energy absorbed in the impact – the fracture toughness.

The hammer is released from a height of 13.0 cm above the lowest point of the swing.

Calculate the momentum of the hammer when it strikes the sample.

mass of hammer = 31 kg

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Momentum of hammer = ...

(Total for question = 3 marks)

Q12.

* 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.

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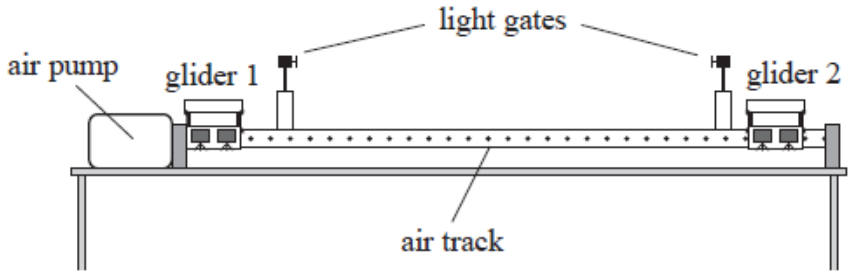
(Total for question = 4 marks)

Q13.

A teacher uses a linear air track to provide a frictionless surface for two gliders, each of mass *m*. She uses this, with a pair of light gates connected to a computer, to investigate a collision between the gliders.

The gliders are each given a small push and travel towards the centre of the track. The gliders collide and move off together.



The teacher asked a student to justify the change in velocity of glider 1 using Newton's laws of motion.

The student began his explanation with the statement:

"During the collision there is a force on glider 2"

Complete the explanation to justify the change in velocity of glider 1, making reference to Newton's laws of motion where appropriate.

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(Total for question = 4 marks)

Q14. * In 2012 Neil Armstrong, the first man to step on the moon during the Apollo 11 lunar mission, died at the age of 82.

During this mission, a planned explosion caused the separation of the module in which Armstrong was travelling and the final-stage rocket. This explosion resulted in an increase in the speed of the module.

Discuss how the conservation of momentum and the conservation of energy apply to this situation.

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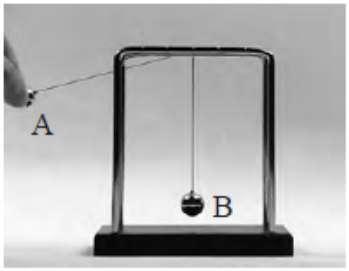
(Total for Question = 5 marks)

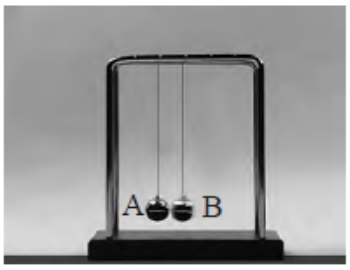
Q15.

Two small identical solid metal spheres, A and B, are suspended by light inextensible threads from a frame.

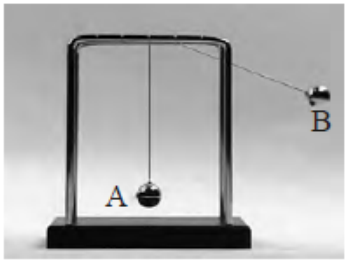
* Sphere A is pulled to one side as shown and released. Sphere A collides with sphere B and stops and sphere B swings upwards. The time intervals between the photographs below are the same.



Photograph 1



Photograph 2



Photograph 3

Using Newton's laws of motion, explain the motion of the spheres during the collision in terms of the forces acting on them.

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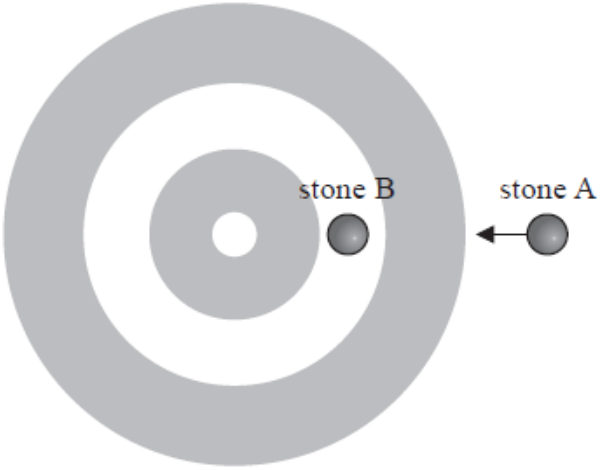
(Total for question = 6 marks)

Q16.

In the sport of curling, two teams of 'curlers' take turns sliding polished granite stones across an ice surface towards a circular target marked on the ice.

commons.wikimedia.org

* Stone B is stationary. Stone A travels towards the target and makes a direct hit on stone B as shown. Both stones have mass *m*.



The collision is elastic. Just before the collision stone A has a velocity *v*. After the collision stone B moves off with velocity *v*.

Discuss how the relevant conservation laws apply to this collision.

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(Total for question = 6 marks)

Q17.

* Particle accelerators accelerate particles to very high speeds before collisions occur. New particles are created during the collisions.

Two particles of the same type can undergo two kinds of collision.

Fixed target: a high speed particle hits a stationary particle.

Colliding beams: two particles travelling at high speeds, in opposite directions, collide head-on.

By considering the conservation of energy and momentum, explain which type of collision is able to create a new particle with the largest mass.

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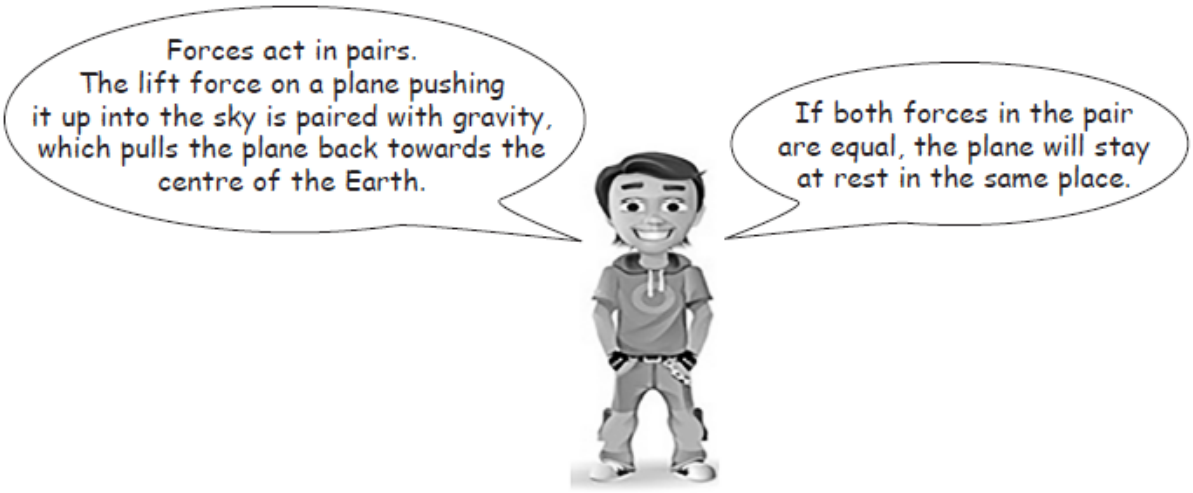
(Total for question = 6 marks)

Q18.

* The following extract comes from a section on forces, on a website written for children.



Criticise this extract.

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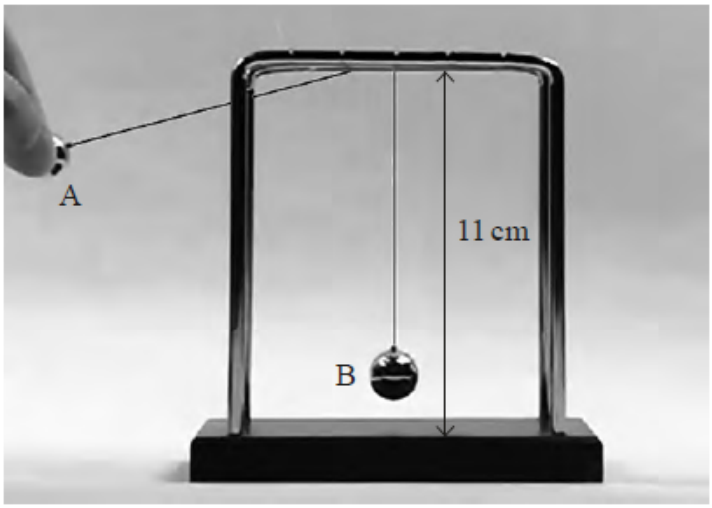
(Total for question = 6 marks)

Q19.

Two small identical solid metal spheres, A and B, are suspended by light inextensible threads from a frame.

The photograph shows sphere A just before it was released.



Determine the momentum of sphere A just before the collision. You should take measurements from the photograph.

height of frame = 11 cm
mass of sphere = 0.022 kg

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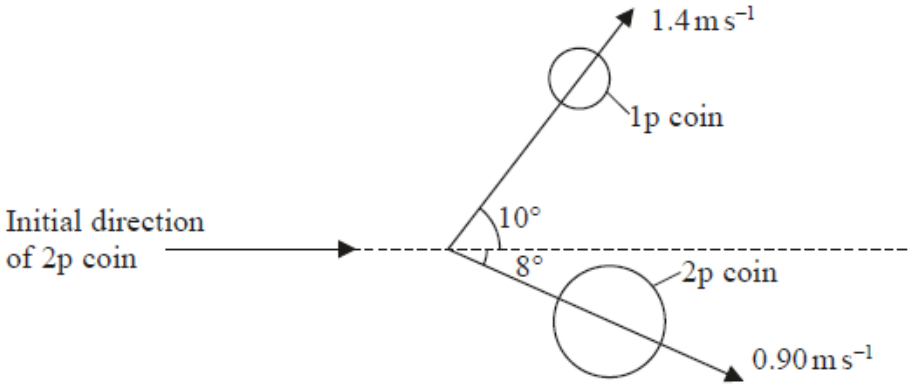
Momentum of sphere A = ...

(Total for question = 5 marks)

Q20.

A student carried out an experiment with coins.

She arranged a collision between a 2p coin and a stationary 1p coin. She noted the directions in which the coins moved after the collision and determined their velocities.



(i) Show that the velocity of the 2p coin just before the collision was about 2 m s^{-1}.

mass of 2p coin = 7.1 g

mass of 1p coin = 3.6 g

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(ii) Show that the collision was inelastic.

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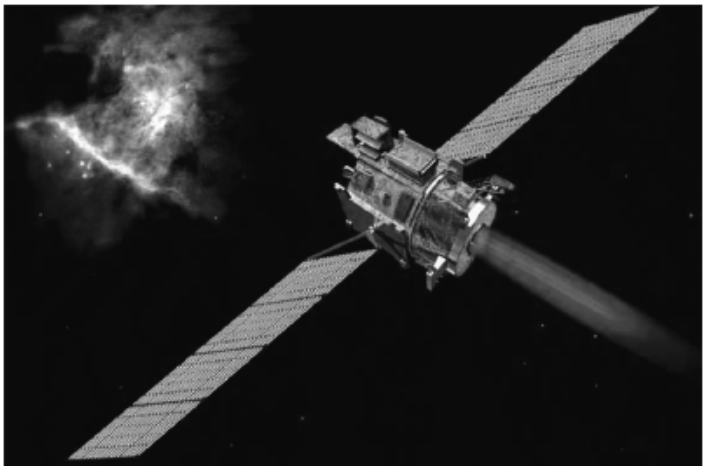
(Total for question = 6 marks)

Q21.

* 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.

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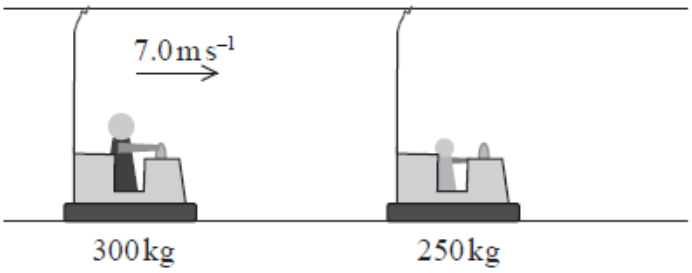
(Total for question = 6 marks)

Q22.

A child in a bumper car travelling at velocity of 7.0ms^{-1} collides with a stationary bumper car directly ahead of him. The diagram shows the bumper cars before the collision.



(a) (i) Assume that the bumper cars move off together after the collision.
Calculate the velocity of the bumper cars after the collision.

(3)

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Velocity = ...

(ii) After travelling 1.3m the cars come to rest.

Calculate the magnitude of the frictional force between the cars and the floor.

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Frictional force = ...

(b) State **one** assumption made in order to carry out the calculation in (a)(i).

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(Total for question = 7 marks)

Q23.

(a) Solar sails are a form of propulsion for spacecraft. The sail is made of a thin sheet of reflective material. When photons of light from the Sun reflect from the material a force is exerted on the sail. The photons reflect with a momentum equal to their initial momentum but in the opposite direction.

(i) Show that a single photon of frequency 1.5×10^{15} Hz has a momentum of about 3×10^{-27} N s.

(2)

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(ii) Hence determine the momentum transferred to the solar sail by this photon.

(1)

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Momentum transferred = ...

(b) An alternative method of producing a momentum change is being investigated. Researchers have suggested that 'larger changes in momentum could be produced by directing laser light at graphene oxide'. Electrons are emitted from the graphene oxide surface, resulting in a force being exerted on the graphene oxide in the opposite direction.

A researcher has suggested that one possible mechanism for the emission of the electrons is the photoelectric effect.

(i) Show that the maximum velocity for a photoelectron emitted after absorption of a photon of light of frequency 1.5×10^{15} Hz is about 8×10^{5} m s^{-1}.

work function of graphene oxide = 6.7×10^{-19} J

(3)

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(ii) Hence calculate the momentum of the photoelectron.

(2)

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Momentum of photoelectron = ...

(c) Explain whether the suggestion in (b) that 'larger changes in momentum could be produced by directing laser light at graphene oxide' is true.

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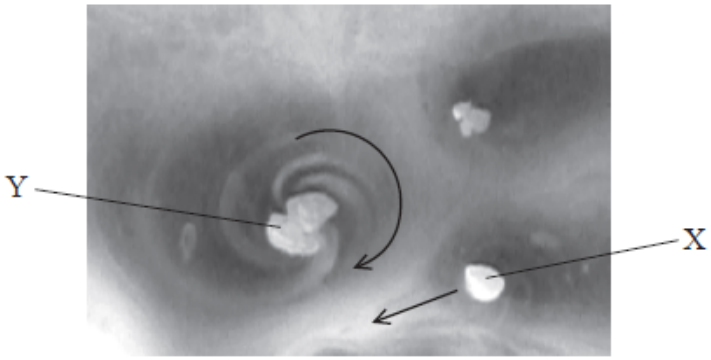
(Total for question = 10 marks)

Q24.

Solid carbon dioxide changes state directly from solid to gas. This process is called sublimation. Solid carbon dioxide, when placed on water, will move rapidly across the surface due to jets of ejected gas.

The diagram below shows the direction of movement for two large pieces of solid carbon dioxide placed on water.



*(a) When placed at rest on water, piece X begins to move rapidly in the direction shown.

With reference to Newton's laws of motion explain the motion of piece X.

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(b) When placed at rest on water, piece Y remained in one position whilst spinning around.

Suggest why piece Y remains in one position.

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(Total for question = 7 marks)

Q25.

The photograph shows a small plastic container, its lid and some pellets of frozen carbon dioxide, known as dry ice. When at room temperature the dry ice gradually changes state directly from solid to gas.

Dry ice is placed in the container and the lid is put on. The container is turned upside down and placed on the floor. After a few minutes the pressure of the gas causes the container to fly into the air, leaving the lid and some dry ice behind.

A student investigated the motion of the container.

(a) The student obtained measurements of the maximum height reached by the container for a particular initial mass of dry ice. The student determined that the maximum height was 2.5 m.

Calculate the initial speed of the container.

(2)

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Initial speed = ...

(b) The student investigated how the maximum horizontal distance travelled by the container varies with launch angle.

Calculate the maximum horizontal distance the container would travel if launched at an initial speed of 6.5 m s^{-1} at an angle of 20° to the horizontal.

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Maximum horizontal distance = ...

(c) The student added dry ice to the container again and placed it on its side on the floor. When the lid was forced off, the container moved forward at a speed of 5.5 m s^{-1} and the lid moved backwards. The pellets of dry ice remained in their original position.

mass of container = 4.3 g
mass of lid = 1.6 g

(i) Calculate the initial speed of the lid.

(3)

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Initial speed of lid = ...

(ii) Explain why the dry ice remained at the original position.

(2)

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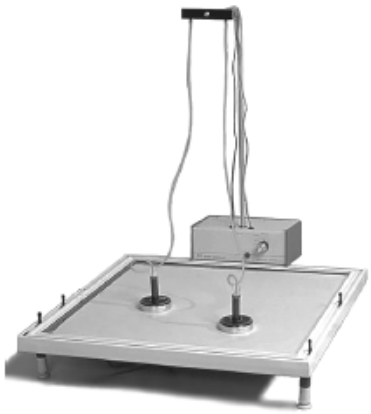
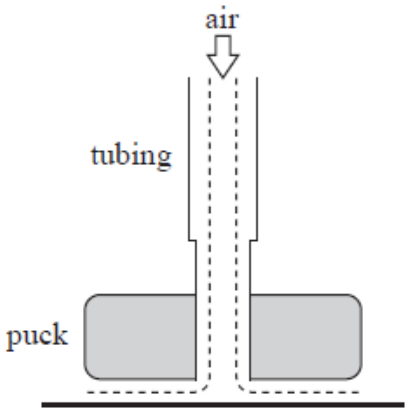
(Total for question = 12 marks)

Q26.

A teacher is demonstrating the principle of conservation of momentum using a flat glass surface and air pucks. Lightweight tubing supplies compressed air to the pucks which is forced out from the bottom of the pucks. This means that the pucks move with very little friction across the glass surface.





(a) Explain, using ideas about molecular movement, how the puck is able to hover a small distance above the glass surface.

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*(b) Applying Newton's 2nd and 3rd laws of motion to the collision between two pucks leads to the conclusion that momentum is conserved.

Justify this statement.

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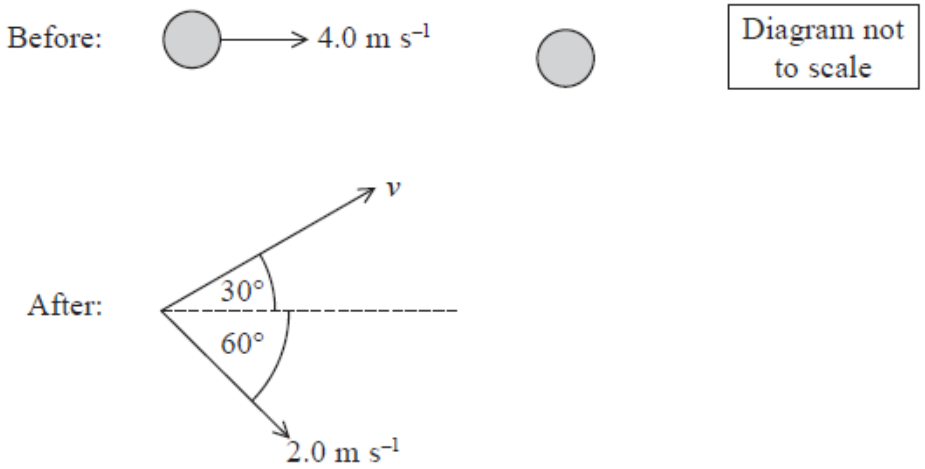
(c) The teacher uses two identical pucks to investigate collisions. In one collision, one puck moves with a velocity of 4.0 m s^{-1} and collides with a second puck that is stationary. After the collision, the first puck has a velocity v at an angle of 30° to its original direction, and the second puck moves off with a velocity of 2.0 m s^{-1} at an angle of 60° to the original direction.



(i) Show that the magnitude of the velocity v of the first puck after the collision is about 3.5 m s^{-1}.

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(ii) Use the data to determine if the collision is elastic or inelastic.

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(Total for question = 16 marks)

Q27. (a) Explain what is meant by the principle of conservation of momentum.

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(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)

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

(1)

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(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)

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(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.

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(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.

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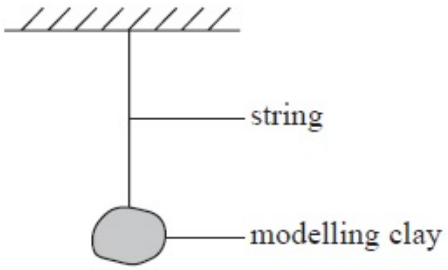
(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



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
= 71.6×10^{-3} kg × 9.81 N kg^{-1} × 0.226 m = 0.16 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.

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(Total for Question = 16 marks)