find attached the second exercise.
The third exercise will require you to read and make skeletal notes on the following
1. Motion of connected bodies
2. work , energy and power.
Enjoy yourself.
A-level you look for 66% yourself.
Find guidance contact my whatsup no. 772 517 813
love and work

NEWTON'S LAWS OF MOTION

LAW I: Everybody continues in its state of rest or uniform motion in **a straight line** unless acted upon by an external force. This is sometimes called the law of **inertia**

Definition

Inertia is the reluctance of a body to start moving once its at rest or to stop moving if its already in motion.

Illustration

Question

Explain why a passenger jerks forward when a fast moving car is suddenly stopped

LAW II: The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of the force.

Definition

Linear momentum (p) is the product of the mass and the velocity of the body moving in a straight line.

Momentum is a vector quantity and its unit is **kgms-1**

The unit of force is **a newton**

Illustration: show that F=ma and define a newton

Note: F must be the resultant force

Applications of F=ma

1. A force of 200N pulls an object of mass 50Kg and overcomes a constant frictional force of 40N. What is the acceleration of the object?
2. A car of mass 1000kg is accelerating at $2ms^{-2}$. What resultant force acts on the car? if the resistance to the motion is 1000N, what is the force due to the engine ?
3. A lift moves (i) up and (ii) down wards with an acceleration of $2ms^{-2}$. In each case calculate the apparent weight of a man of mass50kg standing in the lift.
4. A vehicle has a mass of 600kg. its engine exerts a tractive force of 1500N ,but motion is resisted by a constant frictional force of 300N. Calculate the acceleration of the vehicle.

Applications of Newton's second law of motion

1. Long jumpers bend their knees
2. When catching a fast moving ball , the hands are drawn backwards

Mass and weight

State the differences between mass and weight

LAW III: To every action there is an equal but opposite reactions.
This law stresses that whenever two bodies interact with each other, the force exerted by the first body on the second body is equal and opposite to the force exerted by the second body on the first body

Example of 3rd law of motion

1. A gun moves backwards on firing it.
2. A ball bounces on hitting the ground.

LINEAR MOMENTUM AND IMPULSE

Momentum is the product of mass and velocity of the body moving in a straight line
Momentum (p) = mass x velocity, Momentum is a vector quantity

IMPULSE

This is the product of the force and time for which the force acts on a body
i.e. Impulse (I) = Force(F) x time (t); The unit of impulse is Ns.

Question

Use Newton's second law to show that impulse = change in momentum

Example

1. A body of mass 5kg is initially moving with a constant velocity of 2ms-1, when it experiences
a force of 10N is 2s, find
(i) The impulse given to the body by the force
(ii) The velocity of the body when the force stops acting

2. A body of mass 50kg jumps onto the ground from a height of 2m. Calculate the force whichacts on him when he lands
(i) As he bends his knees and stops within 0.2 seconds
(ii) As he keeps his legs straight and stops within a shorter period of time of 0.05s
3. A ball of mass 0.25kg moving in a straight line with a speed of 2ms-1 strikes a vertical wall at an angle of 45^0 to the normal. The wall gives it an impulse I in the direction of the normal and the ball rebounds at an angle of 60^0 to the normal. Calculate the magnitude of theimpulse and the speed with which the ball rebounds.

LAW OF CONSERVATION OF LINEAR MOMENTUM

It states that for a system of colliding bodies, their total momentum remains constant in a given direction provided no external force acts on them.

Question

Use Newton's laws of motion to prove the law of conservation of momentum

COLLISIONS

In an isolated system, momentum is always conserved but this is not always true of the kinetic energy of the colliding bodies.
In many collisions, some of the kinetic energy is converted into other forms of energy such as heat, light and sound.

Types of collisions

1. Elastic collisions
It is also perfectly elastic collision. This is a type of collision in which all kinetic energy is conserved. E.g collision between molecules, electrons.
2. Inelastic collision
This is a type of collision in which the kinetic energy is not conserved.
3. Completely inelastic collision
This is a type of collision in which the bodies stick together after impact and move with a common velocity. a bullet embedded in a target
4. Explosive collision (super elastic)
This is one where there is an increase in K.E.

Summary

Elastic collision

- Linear momentum is conserved
- Kinetic energy is conserved
- Bodies separate after collision
- Coefficient of restitution (elasticity)=1 (e=1)

Inelastic collision

- Linear momentum is conserved
- Kinetic energy is not conserved
- Bodies separate after collision
- Coefficient of restitution is less than 1 (e<1)

Perfectly inelastic

- Linear momentum is conserved
- Kinetic energy is not conserved
- Bodies stick together and move with a common velocity
- e=0

Mathematic treatment of elastic collision

Consider an object of mass m_1, moving to the right with velocity u_1. If the object makes a head-on elastic collision with another body of mass m_2 moving with a velocity u_2 in the same direction. Let v_1 and v_2 be the velocities of the two bodies after collision. **Show that**

1. $v_2 - v_1 = -(u_2 - u_1)$
2. for $\beta = \frac{m_1}{m_2}$,(a) $\frac{u_1}{v_1} = \frac{\beta+1}{\beta-1}$ (b) $\frac{v_2}{v_1} = \frac{2\beta}{\beta-1}$

Mathematical treatment of perfectly inelastic collision

Suppose a body of mass m_1, moving with velocity u_1 to the right makes a perfectly inelastic collision with a body of mass m_2 moving with velocity u_2 in the same direction. Let v be the common velocity after collision

By law of conservation

Total kinetic energy before collision

Total kinetic energy after collision

Loss in kinetic energy

Numerical examples

1. Ball P, Q and R of masses m_1,m_2 and m_3 lie on a smooth horizontal surface in a straight line. The balls are initially at rest. Ball P is projected with a velocity $u_1$towards Q and makes an elastic collision with Q. if Q makes a perfectly in elastic collision with R, show that R moves with a velocity $v_2 = \frac{2m_1m_2u_1}{(m_1+m_2)(m_2+m_3)}$
2. A 0.2kg block moves to the right at a speed of $1ms^{-1}$ and meets a 0.4kg block moving to the left with a speed of $0.8ms^{-1}$. Find the find velocity of each block if the collision is elastic.
3. A truck of mass 1 tonne travelling at 4m/s collides with a truck of mass 2 tonnes moving at 3m/s in the same direction. If the collision is perfectly inelastic, calculate;
   (i) Common velocity (ii) Kinetic energy converted to other forms during collision

4. Two particles of masses 0.2kg and 0.4kg are approaching each other with velocities $4ms^{-1}$ and $3ms^{-1}$ respectively. On collision, the first particle reverses, its direction and moves with a velocity of $2.5ms^{-1}$. Find the;
(i) Velocity of the second particle after collision (ii) percentage loss in kinetic energy

5. A bullet of mass is fired from a rifle of mass with a muzzle velocity of 100km/h. Find the recoil velocity of the rifle.

6. A bullet of mass 20g is fired into a block of wood of mass 400g lying on a smooth horizontal surface. If the bullet and the wood move together with the speed of 20m/s. Calculate
(i) The speed with which the bullet hits the wood (ii) The kinetic energy lost

BALLISTIC PENDULUM

Illustrations-

Examples

1. A bullet of mass 50g is fired horizontally into a block of wood of mass 8kg which is Suspended by a string of length 2.5m after collision the block swing upwards through an angle 30^0. Calculate the velocity of the bullet assuming that it gets embedded in the block just after collision.
2. A steel ball of mass m is attached to an inelastic string of length 0.6m. The string is fixed to a point P so that the steel ball and the string can move in a vertical plane through P. The string is held out at an angle of 60^0 to the vertical and then released. At Q vertically below P, the wall makes a perfectly inelastic collision with the lump of plasticine of mass 2m so that the two bodies move together after collision

Calculate

(i) The velocity of the composite just after collision

(ii) The position of the composite mass with respect to point Q when the mass first Comes to rest.

(iii) The composite mass now oscillates about the point Q, state two possible reasons why the composite mass finally comes to rest.

3. A bullet of mass 40g is fired horizontally into freely suspended block of wood of mass 1.96kg attached at the end of an inelastic string of length 1.8m. Given that the bullet gets embedded in the block and the string is deflected through an angle of 60^0 to the vertical. Find:

(i) The initial velocity of the bullet An[210m/s]

(ii) The maximum velocity of the block An[42m/s]

4. A bullet of mass 20g travelling horizontally at $100ms^{-1}$ embedded itself in the centre of a block of wood of mass 1kg which is suspended by a light vertical string 1m in length.Calculate the maximum inclination of the string to the vertical . An(36.10)

More Revision Questions on momentum and collisions

1. (i) state the law of conservation of linear momentum

   (ii) A body explodes and produces two fragments of masses m and M. if the velocities of the fragments are u and v respectively, show that the ration of the kinetic energies of the fragments is $\frac{E_1}{E_2} = \frac{M}{m}$, where E_1 is the kinetic energy of m and $E_2$is the kinetic energy of M

2.
   (a) State Newton's laws of motion
   (b) Use Newton's laws of motion to show that when two bodies collide , their total momentum is conserved

(c) Two balls P and Q travelling in the same line in opposite directions with speeds of $6ms^{-1}$ and $15ms^{-1}$ respectively make a perfect inelastic collision. If the masses of P and Q are 8kg and 5kg respectively , find the
   (i) Final velocity of P
   (ii) Change in kinetic energy

(d) (i) What is an impulse of a force?
   (iii) Explain why a long jumper should normally land on sand?

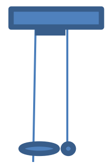
3.
(a) Distinguish between elastic and inelastic collisions
(b) An object X of mass M, moving with a velocity of $10ms^{-1}$ collides with a stationary object Y of equal mass. After collision, X moves with speed U, at an angle of $30^0$to its initial direction, while Y, moves with a speed of V, at an angle of 90^0 to the new direction of X.
   (i) Calculate the speeds U and V
   (ii) Determine whether the collision is elastic or not

4.
(a) Define impulse
(b) A bullet of mass 10g travelling horizontally at a speed of $100ms^{-1}$strikes a block of wood of mass 900g suspended by a light vertical string and is embedded in the b lock which subsequently swings freely . find the
   (i) Vertical height through which the block rises
   (ii) Kinetic energy lost by the bullet

5.
(a) Distinguish between conservative and non –conservative forces
(b) A bullet of 40g is fired from a gun at $200ms^{-1}$and hits a block of wood of mass 2kg which is suspended by a light vertical string 2m long. if the bullet gets embedded in the wooden block,
   (i) Calculate the maximum angle the string makes with the vertical
   (ii) State a factor on which the angle of swing depends

6.
(a) Explain why, when catching a fast moving ball, the hands are drawn back while the ball is being brought to rest.
(b) What are perfectly inelastic collisions?
(c) A car of mass 1000kg travelling at a uniform velocity of $20ms^{-1}$collides perfectly inelastically with a stationary car of mass 1500kg . calculate the loss in kinetic energy of the car as a result of the collision
(d) A car of mass 1500kg rolls from rest down a road inclined to the horizontal at an angle of35^0, through 50m. The car collides with another car of identical mass at the bottom of the incline .If the two vehicles interlock on collision ,and the coefficient of kinetic friction is 0.20, find the common velocity of the vehicles

7. Two pendula of equal length L, have bobs A and B of masses 3M and M respectively. The pendula are hung with bobs in contact as shown



The Bob A is displaced such that the string makes an angle α with the vertical and released. If A makes a perfectly inelastic collision with B, find the height to which B rises.

8. A particle A of mass M_1 travelling with speed u_1 makes a head-on collision with a stationary particle B of mass M_2. If the collision is perfectly elastic and that the speeds of A and B after impact are respectively V_1 and V_2, show that for $k = \frac{M_1}{M_2}$, then

   (i) $k = \frac{V_1 + u_1}{u_1 - V_1}$ (ii) $\frac{V_2}{V_1} = \frac{2k(k+1)}{k^2 - 1}$

9. A particle X of mass M_1 moving at speed $u_1$collides head on with a stationary particle Y of mass M_2. If the collision is elastic and the speeds of X and Y after impact are $V_1$and V_2 respectively, show that if $A = \frac{M_1}{M_2}$, then (i) $\frac{u_1}{V_2} = \frac{1}{2}(1 + A)$ (ii) Y gains $\frac{4A}{(1+A)^2}$ of the total energy.

10. A body A of mass M_1 moving at a speed u_1 makes a perfectly elastic collision with a stationary body B of mass M_2. If $V_1$and V_2 are the velocities of A and B respectively after collision , show that ; (i) $V_1 = \left(\frac{M_1 - M_2}{M_1 + M_2}\right)u_1$ or $V_1=u_1$

   (ii) $V_2 = \frac{2M_1 u_1}{M_1 + M_2}$

11. Water issues horizontally from a horse of cross –sectional area of $5cm^2$at a speed of $10ms^{-1}$. The water hits a vertical wall without rebounding. Find the magnitude of the force acting on the wall .(density of water $=1000kgm^{-3}$)