Chapter#3

Dynamics- 1

Q#1 Define Dynamics?

Ans: Dynamics considers the forces that effects the motion of moving objects and system.

For Example: when an object is thrown vertically upward:

Q1 In dynamics we study why it's motion straight line? Etc

Q# 2 Define the term force?

Ans: Force Is vector quantity which changes or tends to change state of body

- ⇨ start or stop its motion,
- ⇨ speed it up or slow it down
- ⇨ can change the direction of its motion.
- ⇨ Its SI unit is newton. (N)

Q#3 How many types of forces are there?

Ans Forces are classified into two groups.

1) Contact force
2) Non contact force.

⇨ **Contact force**:

The force acting between two objects that are in physical contact are termed as contact forces.

For example:

In game of cricket a batter hitting a cricket ball is a contact force since there is physical contact is between the bat and the ball.

⇨ **Non- Contact force:**

The force acting between two objects that are without any physical contact are termed as non- contact forces.

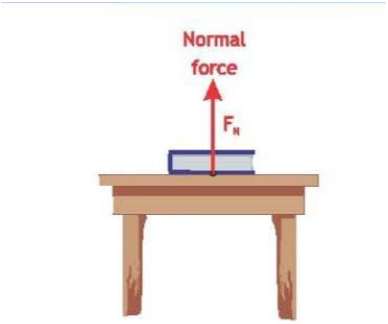
For example:

⇨ The Gravitational force between b/w human and earth are termed as non-contact force.

Q# 4 what is normal force?

Ans: A force perpendicular to the contact surface that keeps objects from passing through each other is called the normal force.(In geometry, normal means perpendicular).

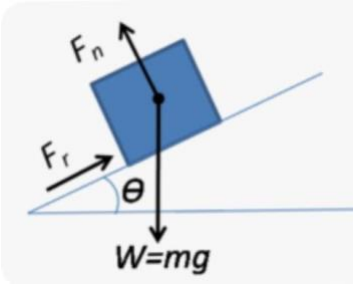
For example the book lying on table, the force perpendicular to the table is normal force.



Q#5 Is Normal force is always equal to weight of body?

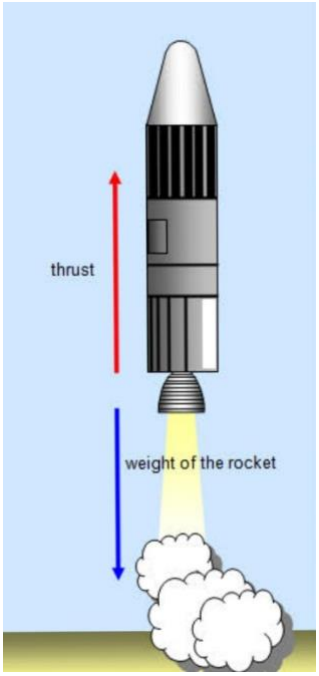
Ans: The Normal force may not equal to weight of the body.

For example : if the table is surface of the table is not horizontal, the normal force is not vertical and is not equal in magnitude to the weight of the body.



Q# 6 what is thrust force?

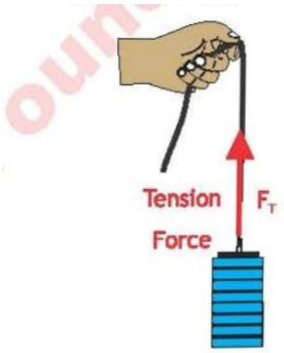
Ans: The force that propels a flying machine in the direction of motion is termed as thrust. For example: engines produce thrust, the thrust of engine of car cause it to accelerate



Q#7 What is meant by Tension force?

Ans: The forces exerted by two or more physical objects that are in contact, through string, rope, cable or spring, we call such force as tension.

For example: The tension in cord attached to a string is shown:



(d) Tension Force

Q#8 What is meant by fundamental forces in nature?

Ans; In physics, Any of four forces

1) Electromagnetic.

2) Gravitational

3) Weak Nuclear

4)/Strong Nuclear

That govern how objects or particle interact and how certain particles decay. All the known forces can be traced to these fundamental forces. The forces whose origin is unknown, is known as fundamental or basic force.

Q# 9 White properties of basic forces.

- ⇨ **GRAVITATIONAL, FORCE:-**
  1) It is a long Range force in nature.
  2) It give rises to the ocean video.
  3) it is always attractive in nature.
  4) If It spreads upto infinitely, but becomes with distance.
  5) If It is responsible for keeping man, atmosphere and sea etc fixed on Earth.
  6) Gravitational force is theorized to be am exchange force with a massless mediating particle great “gravitation”
- ⇨ **ELECTROMAGNETIC FORCE:-**
  1) It is a long Range force.
  2) It can be attractive or repulsion.

3) It has infinite Range and is about 10^{36} times strength than the earth's gravitational field.
4) It causes all chemical Reactions, fractions, cohesion and adhesion are due to this force atoms molecules by the electromagnetic force
5) It is mediated by a massless particle known as "photon".

⇨ **WEAK NUCLEAR FORCE:-**

1) It is repulsive force nature.
2) It is force of very shoot Range 10^{-12}.
3) It is responsible for spontaneous breaking up of Radio active elements.
4) It plays very important role in the structure of universe.
5) It is an exchange force mediated by exchange of three particles called vector "bosons'

⇨ **Strong Nuclear force:**

1) It is short Range force i.e. 10^{-15} m (diameter of proton)
2) It is basically attractive but affectively repulsive in some circumstances.
3) It is responsible for keeps neutrons and protons inside the nucleus.
4) It is effective only within sub Nuclear distance.
5) The exchange particles of strong force are called "pions" with other heavy particles.

Q#10How many types of force diagrams are there?

Ans: Commonly two types of force diagrams,

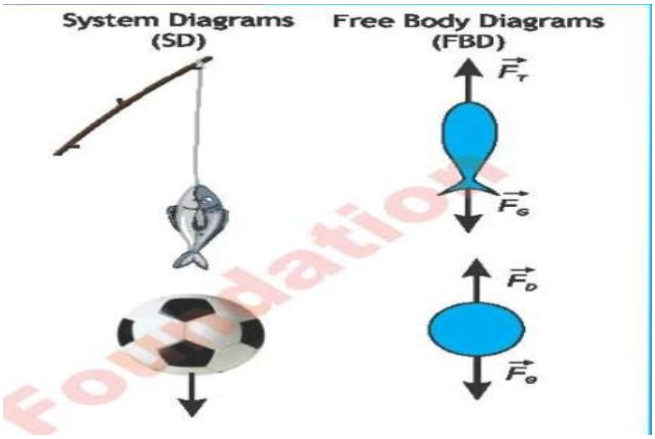
1) System diagrams
2) Free-body diagrams.

⇨ System diagrams:

A system diagram (SD) is a visual expression of all the objects required.

⇨ Free body diagrams:

A free-body diagram (FBD) is a schematic representation in which only the object being analysed is drawn, with arrows showing all the forces acting on the object.



Q# 11 what is meant by Net- force?

Ans: Different forces can affect an object, and the net force is the total effect of all these forces. It is calculated by adding up all the forces acting on the object.

- ⇨ The net force helps us determine if the forces on the object are balanced or unbalanced.
- ⇨ If the net force is O N, it means the forces are balanced, and there will be no change in the object's motion.
- ⇨ If the net force is not zero its mean body is unbalanced and there will be a motion.

Q# 12 what is meant by Resultant force?

Ans: A resultant force is a single force that has the same effect as the combined effect of all the forces to be added.

Q# 13 How we add forces?

Ans: Force is a vector Quantity and it can be added by using Head-to -tail rule.

Q# 14 Explain head to tail rule?

Ans: following steps must be taken in order to add vectors using head to tail rule:

- ⇨ First select a suitable scale.
- ⇨ Then draw the vectors of all the forces according to the scale; such as vectors A and B.
- ⇨ Take any one of the vectors as first vector e.g., vector A.
  Then draw next vector B such that its tail coincides with the head of the first vector A.
- ⇨ Similarly draw the next vector for the third force (if any) with its tail coinciding with the head of the previous vector and so on.

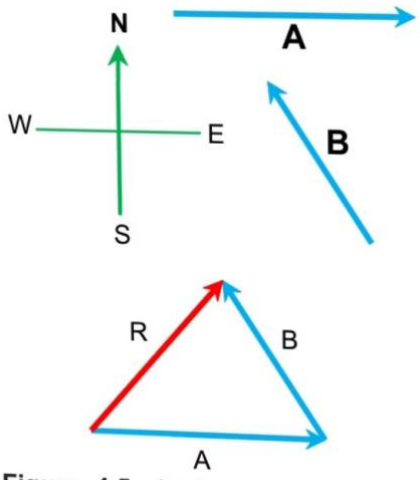


Figure 4.5: Adding vectors by head to tail rule.

Q# 15 Write a detail note on Newton's 1st law of motion?

Ans: Definition :

If the net external force acting on an object is zero, the object will maintain its state of rest or uniform motion (constant velocity).

Explanation:

It means that in absence of external net force, an object at rest, it will remain at rest; While an object in motion will continue to move with constant velocity (no change in velocity or no acceleration).

Mathematically:

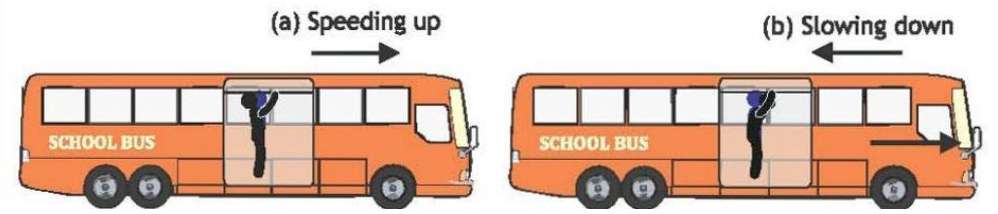
$$\vec{F}_{net} = 0 \quad \text{then} \quad \Delta\vec{v} = 0 \quad \text{or} \quad \vec{a} = 0$$

Law of inertia:

Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as law of inertia.

Example:

Newton's first law of motion is applied when we ride standing in the aisle of a bus holding a pole. As the bus begins to move, we tend to remain at rest, therefore we feel a push to back (as our lower body start moving with the bus, but the upper part of body maintains the state of inertia). The same principle is again at work when the bus start to slow down or stops, we feel to move forward due to inertia as shown.



Q# 16 Write limitation of Newton's 1st law of motion?

Ans: Following are the limitations of Newton's 1st law:

- ⇨ Newton's laws are not valid in a non-inertial frame or object is moving with uniform acceleration.
- ⇨ Not applicable in a non-inertial (accelerated) frame of reference.
- ⇨ Newton's laws are only applicable to point objects and to rigid bodies.

Q# 17 what are conditions for Newton's 1st law?

Ans: There are two conditions on which the 1st law of motion is dependent:

- **Objects at rest:** When an object is at rest, velocity (v = 0) and acceleration (a = 0) are zero. Therefore, the object continues to be at rest.
- **Objects in motion:** When an object is in motion, velocity is not equal to zero (v ≠ 0), while acceleration (a = 0) is equal to zero. Therefore, the object will continue to be in motion with constant velocity and in the same direction

Q# 18 Write a detail note of Newton's 2nd law of motion?

Ans: Definition:

- ⇨ The acceleration produced by a net force acting on an object (or mass) is directly proportional to the magnitude of the force (and in the direction of the force. In other words, the greater the unbalanced net force, the greater the acceleration.
- ⇨ The acceleration of an object being acted on by a net force is inversely proportional to the mass of the object. That is, for a given unbalanced net force, the greater the mass of an object, the smaller the acceleration.

If a force produces an acceleration a in a body of mass m, then we can state mathematically that

$$a \propto F$$

and $$a \propto \frac{1}{m}$$

or $$a \propto \frac{F}{m}$$

or $$F \propto ma$$

Putting k as proportionality constant, we get

$$F = kma$$

In SI units, the value of k comes out to be 1. Thus

$$F = ma$$

SI unit of force is newton (N). According to Newton's second law of motion:

Example:

- ⇨ Acceleration of the rocket is due to the force applied, known as thrust, and is an example of Newton's second law of motion.
- ⇨ Another example of Newton's second law is when an object falls from a certain height, the acceleration increases because of the gravitational force.

Q# 19 Define newton?

Ans: One newton (1 N) is the force that produces an acceleration of 1 m/s^2 in a body of mass of 1 kg.

$1\ N = 1 kgm/s^2$

Q# 20 what are the limitations of Newton's 2nd law of motion?

Ans: Some limitation's of 2nd law are:

- ⇨ Newton's laws are not readily applied on the very small scale. As one goes to extremely low energies on the atomic scale, position and acceleration are not well defined, where the concepts of quantum mechanics takes over.
- ⇨ Newton's laws are not applied for objects moving at high speed (speeds close to the speed of light) relativistic effects complicate the dynamics at high speeds and high energies. In such situations we would require to use relativistic mechanics.

Q# 21 Write a detail note on Newton's 3rd law of motion.

Ans: Definition:

Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.

When an object 'A exert force on object 'B written as F(AB) object 'B' also exert equal force on object 'A written as 'F(BA)but in opposite direction.

Mathematically:

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Here negative sign shows that forces are in opposite direction.

Explanation:

These two forces are termed as action - reaction pair. Action and reaction cannot cancel each other because they act on different bodies (action on one body and reaction on another body).

Example:

When we jump, our legs apply a force to the ground, and the ground applies an equal and opposite reaction force that pushes us into the air.

Q# 22 What are the conditions of newton's 3rd law of motion?

Ans: There are two conditions of Newton's 3rd law of motion:

- ⇨ Action and reactions acts on two different bodies.
- ⇨ Action and reaction acts on different time. First action takes place than its equal and opposite reaction take place.

Q# 23 What are limitations of Newton's 3rd law of motion?

Ans: Some limitation's of 3rd law includes:

- ⇨ Forces within an object, like electrostatic attractions between atoms, do not have external equal and opposite reaction forces.
- ⇨ The frictional force that resists the motion of objects in contact is not strictly equal to the force applied.

Q# 24 Difference between mass and weight?

Ans:

Mass:

- ⇨ Mass of a body is the quantity of matter possessed by the body.
- ⇨ It is a scalar quantity and does not change with change of place.
- ⇨ It is measured by comparison with standard masses using a beam balance.
- ⇨ Its SI unit is kg.
- ⇨ It is base Quantity.

Weight:

- ⇨ Weight of a body is the force equal to the force with which Earth attracts it.
- ⇨ It varies depending upon the value of g, acceleration due to gravity.
- ⇨ Weight is a force and thus it is a vector quantity.
- ⇨ Its SI unit is newton (N); the same as force.
- ⇨ Weight is measured by a spring balance.

Q# 25 Write a note on spring balance?

Ans: Spring scale is a device used for measuring the force acting on an object. It consists of a spring which gets stretched when a force is applied to it. Stretching of the spring is measured by a pointer moving on a graduated scale. The reading on the scale gives the magnitude of the force.

(a) Spring balance

Q# 26 Write a note on force sensor?

Ans: The force sensor uses an electronic gauge to measure force measure force with a high degree of accuracy. It gives a digital readout or a graph of the forces when interfaced with a computer.

(b) Force sensor

Q# 27 what is meant by Gravitational field?

Ans: The region around a non contact forces where a magnetic force is operative 15 termed as force field. Whereas the region around a massive object (such as earth, sun etc.) where gravitational force is operative termed as gravitational field.

Q# 28 What is meant by Gravitational field strength?

Ans: The gravitational field strength is the amount of force per unit mass acting on objects in the gravitational field. The value of 'g' is equal to the magnitude the gravitational force exerted on a unit mass at that point,

Mathematically

$$g=Fg/m.$$

The gravitational field strength (g) is a vector with a magnitude of 'g' that points in the direction of the gravitational force.

SI unit and direction

In SI units, gravitational field strength is measured in newton per kilogram (N/kg). It is a vector quantity that has the direction downward or toward the centre of Earth.

- ⇨ The gravitational field strength is not the same everywhere. Gravitational force decrease as we move away from the surface of earth, therefore gravitational field strength also decreases.

Q# 29 Define the term momentum

Ans: Definition:

Momentum of a body is the quantity of motion it possesses due to its mass and velocity.

Mathematically:

The momentum P of a body is given by the product of its mass m and velocity v.

Thus $P = mv$

Quantity and Unit:

Momentum is a vector quantity. Its SI unit is kgm/s.

Q# 30 Write Relation between force and momentum?

OR

Prove that rate of change of momentum is equal to applied force?

OR

How can you relate a force with the change of momentum of a body?

Ans: Consider a body of mass m moving with initial velocity 'vi'. Let a force F acts on the body which produces an acceleration 'a' in it. This changes the velocity of the body. Let its final velocity after time becomes 'vf'. If 'Pi' and 'Pf' be the initial momentum final momentum of the body related to initial and final velocities respectively thus:

$$P_i = mv_i$$

and $$P_f = mv_f$$

$\therefore$ Change in momentum = final momentum − initial momentum

or $$P_f - P_i = mv_f - mv_i$$

Thus the rate of change in momentum is given by:

$$\frac{P_f - P_i}{t} = \frac{mv_f - mv_i}{t}$$

$$= m\,\frac{v_f - v_i}{t}$$

since $\frac{v_f - v_i}{t}$ is the rate of change of velocity equal to the acceleration a produced by the force F.

$$\therefore \quad \frac{P_f - P_i}{t} = m\,a$$

According to Newton's second law of motion,

$$F = ma$$

or $$\frac{P_f - P_i}{t} = F$$

For example,

Catching a ball with your bare hands will hurt depending on the force of the ball. However, if you allow your hands to move with the ball as you catch it, duration of time *t' will increase, and force will be smaller, and your hands will hurt less.

Q# 31 Define the term impulse?

Ans: Newton's second law enable us to write force and change in momentum relation as:

$$\vec{F}_{net} = \frac{\vec{p}_f - \vec{p}_i}{\Delta t} = \frac{\Delta \vec{p}}{\Delta t}$$

$$\vec{F}_{net} \times \Delta t = \Delta \vec{p}$$

Equation enable us to define a new quantity termed as 'impulse, Impulse is the product of the force exerted on an object and the time interval over which the force acts, and is often given the symbol 'j'. Impulse is a vector quantity, and the direction of the impulse is the same as the direction of the force that causes it, and have the same SI units as momentum.(Ns)

Q# 32 Difference between action and reaction?

Ans:

Action:

- ⇨ Action as an act of the will, something done or performed, or the accomplishment of a task.
- ⇨ It is also called applied force.
- ⇨ It occurs first.

Reaction:

- ⇨ A reaction is defined as the way someone acts or feels in response to something that happens or is said.
- ⇨ It is Reaction of applied force.
- ⇨ It occurs after the action.

Q# 33 what is meant by isolated system?

Ans: Group of bodies or particles, under study System U separated by a boundary is called as a system. If the net external force on the system is zero, oundary: it is termed as isolated system.

Q. Write a detailed note on law of Conservation of momentum.

ISOLATED SYSTEM :-

A isolated system is said to be isolated if no external force act on it. i.e the Sum of external force is zero.

STATEMENT :-

The momentum of isolated system of two or more than two interacting sides remains constant.

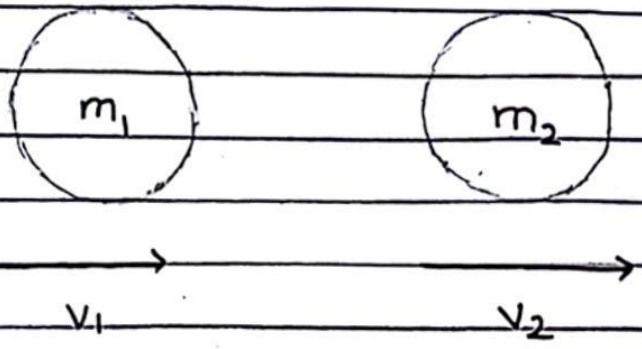
DERIVATION :-

Consider two spheres of mass 'm_1' and 'm_2' moving with velocities 'V_1' and 'V_2' in a straight line respectively such that m_1 has greater velocity as compared to m_2.

Initial momentum of $m_1 = P_1 = m_1 V_1$

Intial momentum of $m_2 = P_2 = m_2 V_2$

Total initial momentum $= m_1 V_1 + m_2 V_2$



After some time m_1 hits m_2 So velocities changed, new velocities are V_1 and V_2

final momentum of m_1 is $= P_1 = m_1V_1$

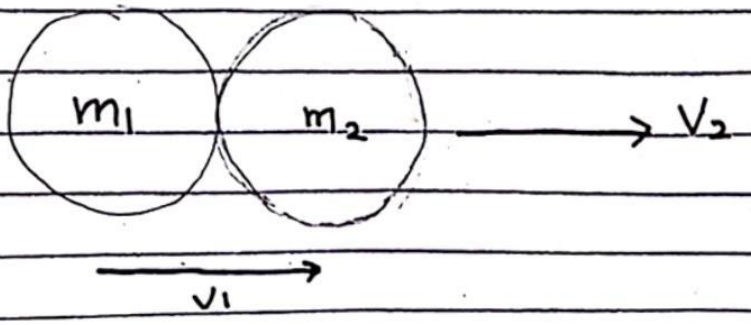
final momentum of m_2 is $= P_2 = m_2V_2$

Total final momentum $= m_1V_1 + m_2V_2$

According to law of conservation of momentum :—

Total initial = Total final momentum

$$mV_1 = m_1V_1 + m_2V_2$$



EXAMPLE :-

Consider a system of Gun and bullet before firing the Gun and bullet at rest. So momentum is zero. After fixing the Gun, bullet gets momentum to conserve this, momentum gun recoils.

APPLICATION :-

Rockets and jet engine work on the principle of law of conservation of momentum.

Q2: When bullet is fired, gun recoils. Calculate the recoiling velocity of the Gun.

Ans: Consider an isolated System of bullet of mass 'm_g' and mass of gun 'm_i' before firing both gun and bullet at rest of V_B and V_a are zero

$$P_i = M_B V_B + M_G V_G$$
$$P_i = M_B (0) + M_G (0)$$
$$P_i = 0 + 0$$
$$P_i = 0$$

After fixing bullet moves with velocity 'V_B' in one direction, to converse momentum gun recoils with velocity V_G. So,

$$P_f = m_B V_B + m_G V_G$$

According to the law of conservation of momentum.

$$P_i = P_f$$

$$0 = m_B V_B + M_G V_G$$

$$m_B V_B = m_G V_G$$

$$\frac{m_B V_B}{m_G} = V_G$$

Q22: Define Collision also give examples

Ans: When particles in an isolated system come closer to each other and interact by mean of force, it is called collision.

EXAMPLE :-

When two rail road cars being completed together, A failing object and a floor.

Conceptual Questions:

Q# **1. When a motor cyclist hit a stationary car, he may fly off the motor cycle and driver in the car may get neck injury. Explain**

Ans: When a motor cyclist hits a stationary car then he cannot stop himself due to inertia and continue his state of motion so he may fly off the motor cycle.

While the driver in the car is at rest. When the motor cyclist hits the car then the upper part of the driver wants to stay at rest due to inertia, but his lower part moves with the car with a force produced of collision. So the driver in the car may get neck injury.

Q# 2. In autumn, when you shake a branch, the leaves are detached. Why?

Ans: In autumn, when we shake a branch, the leaves get detached. Because when a tree IS forcefully shaken, the branches of the tree come in motion but the leaves tend to continue in their state of rest due to inertia. As a result of this, leaves get separated from the branches of the tree and hence fall down.

Q# 3. Why it is not safe to apply brakes only on the front wheel of a bicycle?

Ans: If we apply brakes only on the front wheel of a bicycle then the bike lifts the rear wheel which may cause of an accident. It is due to inertia that the rear wheel wants to continue its motion but when we brake, our weight is being shifted towards the front wheel. The inertia coupled with gravity puts our weight and that of the bike onto the front wheel. More weight means more friction/grip with the ground.

So the front wheel stops immediately, but rear wheel lifts up which may cause of an accident.

Q# 4, Deduce Newton's first law of motion from Newton's second law of motion?
Ans: According to Newton's 2nd law

$$F = ma$$

$$F = m(v_f - v_i)/t$$

If F=0 then vi=vf . the object continues to move with uniform velocity if no net force is applied. If F=0 & vi= vf then vf is also 0. i.e. the object will stay at rest.

According to Newton's 1st law of motion, an object at rest or uniform motion tends to remain at rest or in uninform motion unless an external applied on it. Hence proved

Q# 5. Action and reaction are equal but opposite in direction. These forces always act in pair. Do they balance each other? Can bodies move under action-reaction pair?

Ans: Balanced forces are equal and opposite forces that act on the same object. That's why they cancel out. Action and reaction forces are equal and opposite forces that act on different objects, so they don't cancel out.

Yes, a body can move under action-reaction pair. For example Rocket moves up when a rocket expels gases downward to propel itself upward, (reaction) the gases exert a downward force on the rocket (action), and the rocket exerts an equal and opposite upward force on the gases (reaction). This reaction force propels the rocket upward. Allowing it to move.

Q# 6. A man slips on the oily floor, he wants to move out of this area. He is alone. He throws his bag to move out of this slippery area. Why is its so?

Ans: When a man slips on the oily floor then he has minimum friction between floor and his feet. He throws his bag to move out of this slippery area. When he throws a bag in one direction then this IS an action, according to third law of motion as a reaction he will move in opposite direction due to less friction. This act helps him to move out from the oily floor.

Q# 7. How would you use Newton's 3rd law of motion and law of conservation of momentum to explain motion of rocket?

Ans: Newton's third law of motion states that to every action there is an equal and opposite reaction. Similarly, when a rocket moves, it exerts the action force on the gases to (reaction) expel them backwards which in turn exerts an equal and – opposite reaction force to move the rocket forward Rocket works on the principle of conservation of momentum. Rocket eject gases in backward direction which creates momentum of the gases backwards and thus by conservation of momentum, the rocket gets momentum in the forward direction making it move Force forward.

Q# 8. Why are cricket batter gloves padded with foam?

Ans: Batsman gloves are padded with foam for protection and provides better friction between the gloves and the bat instead of using cotton, Foam and cotton are the types of materials that are used in the finger padding of batting gloves. Despite being lightweight, foam offers the same level of protection as cotton padding. Batsman can better hold the bat due to the finger cut outs which add extra wrap around the handle due to enough friction between gloves and bat.

Also force= change of momentum/time

It increases the impact time which force is small.

Q# 9 . Where will your weight be greater, near earth or near moon? What about mass?

Ans:

Weight:

We know that weight depends on the value of gravitational acceleration g. As the value of g is greater on Earth then on Moon so the weight near Earth will be greater than Moon.

Mass: Mass remains same everywhere So the mass will be same on Earth and Moon.

Q# 10 10. When Ronaldo kicks the ball, at the highest point of ball both Earth and ball attract each other with the same magnitude of force. Why then the ball moves towards Earth and not the Earth?

Ans: When Ronaldo kicks the ball, at the highest point of ball both Earth and ball attract each other with the same magnitude of force. The motion S determined by their masses. The ball moves towards Earth because it has much less mass than the Earth, so its acceleration due to gravity is much greater, as per Newton's second law (F = ma).

Numerical Response Questions:

1. A boy is holding a book of mass $2kg$. How much force is he applying on the book? If he moves it up with acceleration of $3ms^{-2}$, How much total force should be apply on the book?

Data:

$m = 2kg$

$F = ?$

$a = 3ms^{-2}$

$F_t = ?$

Solution:

$F = W$

$F = mg$

$F = (2)(9.8)$

$\boxed{F = 19.6N}$

$F = ma$

$F = (2)(3)$

$F = 6N$

$F_t = 19.6 + 6$ $\quad \boxed{F_t = 25.6N}$

2. A girl of mass $30kg$ is running with velocity of $4ms^{-1}$. Find her momentum.

Data:

$m = 30kg$

$v = 4ms^{-1}$

$P = ?$

Solution:

$P = mv$

$P = (30)(4)$

$\boxed{P = 120Ns}$

3. A 2kg steel ball is moving with speed of $15ms^{-1}$. It hits with bulk of sand and comes to rest in 0.2 second. Find force applied by sand bulk on the ball.

Data:

$m = 2kg$

$v_i = 15ms^{-1}$

$v_f = 0$

$t = 0.2s$

$F = ?$

Solution:

$$a = \frac{v_f - v_i}{t}$$

$$a = \frac{0 - 15}{0.2}$$

$$a = -\frac{15}{0.2}$$

$a = -75ms^{-2}$

$F = ma$

$F = (2)(-75)$ $\quad \boxed{F = -150N}$

4. A 100 grams bullet is fired from $5kg$ gun. Muzzle velocity of bullet is $20ms^{-1}$. Find recoil velocity of the gun.

Data:

$m = 100g = 0.1kg$

$M = 5kg$

$v = 20ms^{-1}$

$V = ?$

Solution:

According to law of conservation of momentum

$$MV = mv$$

$$V = \frac{mv}{M}$$

$$V = \frac{(0.1)(20)}{5}$$

$$\boxed{V = 0.4ms^{-1}}$$

5. A robotic car of $15kg$ is moving with $25ms^{-1}$. Brakes are applied to stop it. Brakes apply constant force of $50N$. How long does the car take to stop?

Data:

$m = 15kg$

$v = 25ms^{-1}$

$F = 50N$

$t = ?$

Solution:

$$F = \frac{\Delta P}{t}$$

$$F = \frac{mv}{t}$$

$$t = \frac{mv}{F}$$

$$t = \frac{(15)(25)}{50}$$

$$\boxed{t = 7.5s}$$