QB365 Question Bank Software Study Materials

Laws of Motion Important 2 Marks Questions With Answers (Book Back and Creative)

11th Standard

Physics

Total Marks : 60

2 Marks

30 x 2 = 60

1) State Newton's second law.

Answer : The rate of change of linear momentum of a body is directly proportional to the external force applied on the body and this change takes place always in the direction of the applied force.

$F=\frac{\vec{d} p}{dt}=\frac{d(m\vec{v})}{dt}=m\frac{d\vec{v}}{dt}=m\vec{a}\left(\text{as } a=\frac{d\vec{v}}{dt}\right)$

$\vec{F}=m\vec{a}\Rightarrow$ Force $=$ mass $\times$ acceleration

2) What is the meaning by 'pseudo force'?

Answer : The centrifugal force appears to act on the particle, only when we analyses the motion from a rotating frame. With respect to an inertial frame there is only centripetal force which is given by the tension in the string. For this reason centrifugal force is called as a 'pseudo force'. A pseudo force has no origin, It arises due to the non-inertial nature of the frame considered.

3) What are inertial frames?

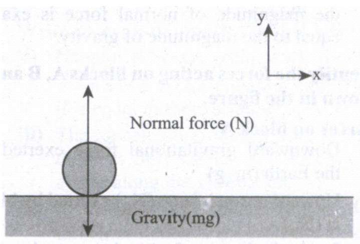
Answer : (a) A frame of reference which is at rest or which is moving with a uniform velocity along a straight line is called an inertial frame of reference.

(b) In the inertial frame of reference Newton's laws of motion holds good.

Example: The 1ift at rest, lift moving (up or down) with constant velocity, car moving with constant velocity on a straight road.

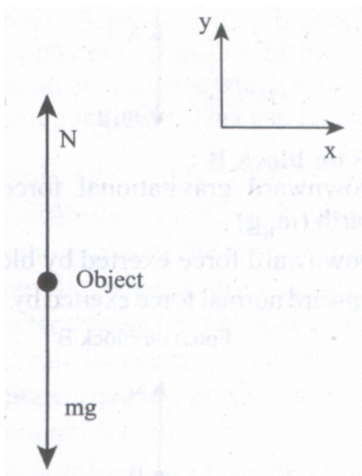
4) Apply Newton's second law for an object at rest on Earth and analyse the result.

Answer : The object is at rest with respect to Earth (inertial coordinate system). There are two forces that act on the object.



(i) Gravity acting downward (negative y-direction)

(ii) Normal force by the surface of the Earth acting upward (positive y-direction) The free body diagram for this object is



$\vec{F}_g=-mg\hat{j}$

$\vec{N}=N\vec{j}$

Net force $\vec{F}_{net}=-mg\hat{j}+N\vec{j}$

But there is no acceleration on the ball

So $\vec{a}$ = 0. By applying newton's second law $\left(\vec{F}_{net}=m\vec{a}\right)$

Since $\vec{a}=0, \vec{F}_{net}=-mg\hat{j}+N\vec{j}$

$(-mg+N)\vec{j}=0$

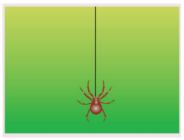
(iii) By comparing the components on both sides of the equation we get,

-mg + N = 0

N = mg

We can conclude that if the object is at rest, the magnitude of the normal force is exactly equal to the magnitude of gravity

5) A spider of mass 50 g is hanging on a string of a cob web. What is the tension in the string?



Answer : T = mg

T = 50g x 9.8m/s^2

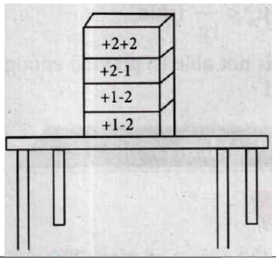
Tension (T) = 0.49 N

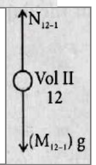
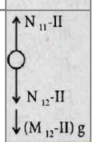
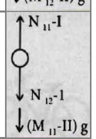
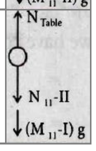
6) The physics books are stacked on each other in the sequence: +1 volumes 1 and 2; +2 volumes 1 and 2 on a table

a) Identify the forces acting on each book and draw the free body diagram.

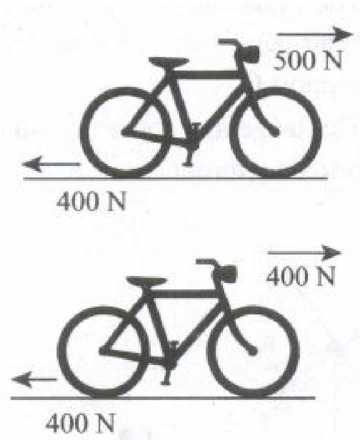
b) Identify the forces exerted by each book on the other

Answer :



Force acting on 12 - Vol - II	
Force acting on 12 - Vol - I	
Force acting on 11- Vol - I	
Force acting on 11 - Vol - II	

7) Calculate the acceleration of the bicycle of mass 25 kg as shown in Figures



Answer :

From Fig (1) we have equation &

F - f_k = m x a

500 - 400 = 25 x a

a = $\frac{100}{25} = 4m/s^2$

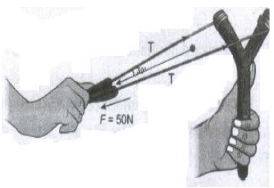
From the Fig.2

F - f_k = m x a

400 - 400 = 25 x a

a = $\frac{0}{25} = 0(zero)$

8) Apply Lami's theorem on sling shot and calculate the tension in each string?



Answer : Force acting vertically to sling shot

Tension T in each string;

Now applying Lami's theorem, we get

$\frac{2T}{\sin\theta} = F$

$\frac{2T}{\sin(2\times30)} = 50N$

$\frac{2T}{\sin(60)} = 50N$

$\frac{2T}{\sqrt{3}} = 50N$

$\frac{T}{2T} = \frac{2}{\sqrt{3}} \times 50N$

$T = \frac{50N}{\sqrt{3}} = 28.268N$

9) A person rides a bike with a constant velocity $\vec{v}$ with respect to ground and another biker accelerates with acceleration $\vec{a}$ with respect to ground. Who can apply Newton's second law with respect to a stationary observer on the ground?

Answer : (i) Second biker cannot apply Newton's second law, because he is moving with acceleration $\vec{a}$ with respect to Earth (he is not in inertial frame).

(ii) But the first biker can apply Newton's second law because he is moving at constant velocity with respect to Earth (he is in inertial frame).

10) A book of mass m is at rest on the table.

(1) What are the forces acting on the book?

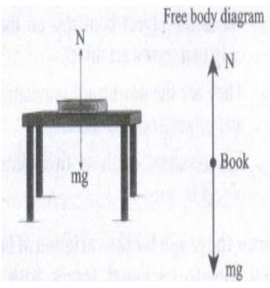
(2) What are the forces exerted by the book?

(3) Draw the free body diagram for the book.

Answer : (1) There are two forces acting on the book.

(i) Gravitational force (mg) acting downwards on the book.

(ii) Normal contact force (N) exerted by the surface of the table on the book. It acts upwards.

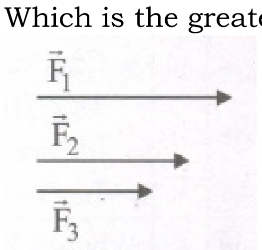


(2) According to Newton's third law, there are two reaction forces exerted by the book.

(i) The book exerts an equal and opposite force (mg) on the Earth which acts upwards.

(ii) The book exerts a force which is equal and opposite to normal force on the surface of the table (N) acting downwards.

11) Which is the greatest force among the three force $\overrightarrow{F_1}, \overrightarrow{F_2}, \overrightarrow{F_3}$, shown below:



Answer : Force is a vector and magnitude of the vector is represented by the length of the vector. Here $\overrightarrow{F_1}$ has greater length compared to other two. So $\overrightarrow{F_1}$ is largest of the three.

12) The position vector of a particle is given by $\vec{r} = 3t\hat{i} + 5t^2\hat{j} + 7\hat{k}$. Find the direction in which the particle experiences net force?

Answer : Velocity of the particle,

$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d}{dt}(3t)\hat{i} + \frac{d}{dt}(5t^2)\hat{j} + \frac{d}{dt}(7)\hat{k}$

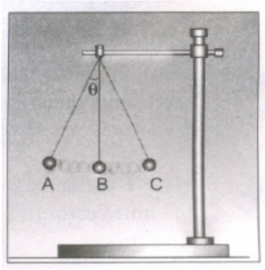
$\frac{d\vec{r}}{dt} = 3\hat{i} + 10t\hat{j}$

Acceleration of the particle

$\frac{d\vec{r}}{dt} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2} = 10\hat{j}$

Here, the particle has acceleration only along positive y direction. According to Newton's second law, net force must also act along positive y direction. In addition, the particle has constant velocity in positive x direction and no velocity in z direction. Hence, there are no net force along x or z direction.

13) Consider a bob attached to a string, hanging from a stand. It oscillates as shown in the figure.



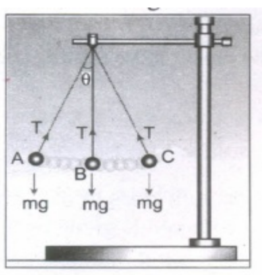
(a) Identify the forces that act on the bob?

(b) What is the acceleration experienced by the bob?

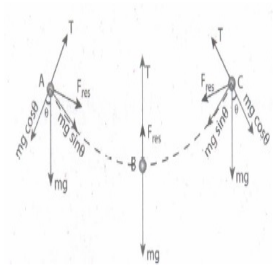
Answer : Two forces act on the bob.

(i) Gravitational force (mg) acting downwards

(ii) Tension (T) exerted by the string on the bob, whose position determines the direction of T as shown in figure.



The bob is moving in a circular arc as shown in the above figure. Hence it has centripetal acceleration. At a point A and C, the bob comes to rest momentarily and then its velocity increases when it moves towards point B. Hence, there is a tangential acceleration along the arc. The gravitational force can be resolved into two components (mg cos θ, mg sin θ) as shown below:



14) A particle of mass 2 kg experiences two forces, $\overrightarrow{F_1} = 5\hat{i} + 8\hat{j} + 7\hat{k}$ and $\overrightarrow{F_2} = 3\hat{i} - 4\hat{j} + 3\hat{k}$. What is the acceleration of the particle?

Answer : We use Newton's second law, $\overrightarrow{F_{net}} = m\vec{a}$ where $\vec{F}_{net} = \overrightarrow{F_1} + \overrightarrow{F_2}$. From the above equations the acceleration is $\vec{a} = \frac{\overrightarrow{F_{net}}}{m}$, where

$\overrightarrow{F_{net}} = (5+3)\hat{i} + (8-4)\hat{j} + (7+3)\hat{k}$

$\vec{F}_{net} = 8\hat{i} + 4\hat{j} + 10\hat{k}$

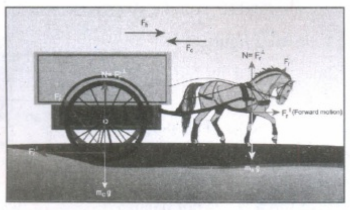
$\vec{a} = \left(\frac{8}{2}\right)\hat{i} + \left(\frac{4}{2}\right)\hat{j} + \left(\frac{10}{2}\right)\hat{k}$

$\vec{a} = 4\hat{i} + 2\hat{j} + 5\hat{k}$.

15) Consider a horse attached to the cart which is initially at rest. If the horse starts walking forward, the cart also accelerates in the forward direction. If the horse pulls the cart with force F_h in forward direction, then according to Newton's third law, the cart also pulls the horse by equivalent opposite force $F_c = F_h$ in backward direction. Then total force on 'cart+horse' is zero. Why is it then the 'cart+horse' accelerates and moves forward?

Answer : This paradox arises due to wrong application of Newton's second and third laws. Before applying Newton's laws, we should decide 'what is the system?'. Once we identify the 'system', then it is possible to identify all the forces acting on the system. We should not consider the force exerted by the system. If there is an unbalanced force acting on the system, then it should have acceleration in the direction of the resultant force. By following these steps we will analyse the horse and cart motion.

If we decide on the cart+horse as a 'system', then we should not consider the force exerted by the horse on the cart or the force exerted by cart on the horse. Both are internal forces acting on each other. According to Newton's third law, total internal force acting on the system is zero and it cannot accelerate the system. The acceleration of the system is caused by some external force. In this case, the force exerted by the road on the system is the external force acting on the system. It is wrong to conclude that the total force acting on the system (cart+horse) is zero without including all the forces acting on the system. The road is pushing the horse and cart forward with acceleration. As there is an external- force acting on the system, Newton's second law has to be applied and not Newton's third law. The following figures illustrates this.



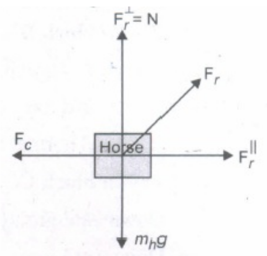
If we consider the horse as the 'system', then there are three forces acting on the horse.

(i) Downward gravitational force ($m_h g$)

(ii) Force exerted by the road (F_r)

(iii) Backward force exerted by the cart (F_c)

It is shown in the following figure.



F_r - Force exerted by the road on the horse

F_c - Force exerted by the cart on the horse

$F^{\perp}{}_r$-Perpendicular component of F_r=N

$F^{||}{}_r$-Parallel component of Fr which is reason for forward movement.

The force exerted by the road can be resolved into parallel and perpendicular components. The perpendicular component balances the downward gravitational force. There is parallel component along the forward direction. It is greater than the backward force (F_c). So there is net force along the forward direction which causes the forward movement of the horse.

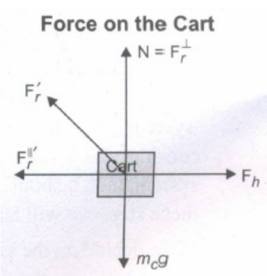
If we take the cart as the system, then there are three forces acting on the cart.

(i) Downward gravitational force ($m_c g$)

(ii) Force exerted by the road (F_r)

(iii) Force exerted by the horse (F_h)

It is shown in the figure.



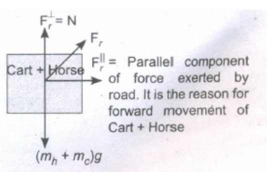
The force exerted by the road ($\overrightarrow{F_r}$) can be resolved into parallel and perpendicular components. The perpendicular component cancels the downward gravity ($m_c g$). Parallel component acts backwards and the force exerted by the horse ($\overrightarrow{F_h}$) acts forward. Force ($\overrightarrow{F_h}$) is greater than the parallel component acting in the opposite direction. So there is an overall unbalanced force in the forward direction which causes the cart to accelerate forward.

If we take the cart+horse as a system, then there are two forces acting on the system.

(i) Downward gravitational force $(m_h + m_c)g$

(ii) The force exerted by the road (F_r) on the system.

It is shown in the following figure.



(iii) In this case the force exerted by the road (F_r) on the system (cart+horse) is resolved in to parallel and perpendicular components. The perpendicular component is the normal force which cancels the downward gravitational force $(m_h + m_c)g$. The parallel component of the force is not balanced, hence the system (cart+horse) accelerates and moves forward due to this force.

16) The position of the particle is represented by $y = ut - \frac{1}{2}gt^2$

(a) What is the force acting on the particle?

(b) What is the momentum of the particle?

Answer : To find the force, we need to find the acceleration experienced by the particle.

Th e acceleration is given by $a=\frac{d^2y}{dt^2}$ or $a=\frac{dv}{dt}$

Here v = velocity of the particle in y direction

$v = \frac{dy}{dt} = u - gt$

The momentum of the particle = mv = m(u - gt)

$a = \frac{dv}{dt} = -g$

The force acting on the object is given by F = ma = -mg

The negative sign implies that the force is acting on the negative y direction. This is exactly the force that acts on the object in projectile motion.

17) Consider an object of mass 2 kg resting on the floor. The coefficient of static friction between the object and the floor is $\mu_s = 0.8$. What force must be applied on the object to move it?

Answer : Since the object is at rest, the gravitational force experienced by an object is balanced by normal force exerted by floor.

N = mg

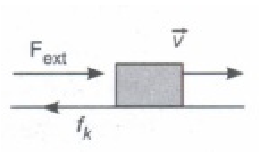
The maximum static frictional force $f_s^{max} = \mu_s N = \mu_s N = \mu_s mg$

$f_s^{max} = 0.8 \times 2$ 9.8 =15.68 N.

Therefore to move the object the external force should be equal to maximum static friction.

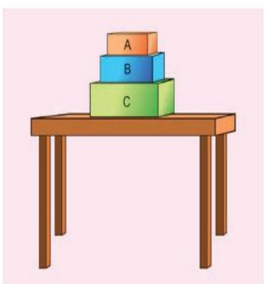
F_{ext} = 15.68 N.

18) Consider an object moving on a horizontal surface with a constant velocity. Some external force is applied on the object to keep the object moving with a constant velocity. What is the net force acting on the object?



Answer : If an object moves with constant velocity, then it has no acceleration. According to Newton's second law there is no net force acting on the object. The external force is balanced by the kinetic friction.

19) Identify the forces acting on blocks A, B and C shown in the figure.

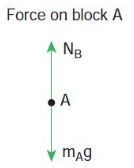


Answer : **Forces on block A:**

(i) Downward gravitational force exerted by the Earth (m_Ag)

(ii) Upward normal force (NB) exerted by book B (N_B)

The free body diagram for book A is as shown in the following picture.

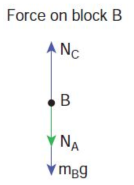


Forces on block B:

(i) Downward gravitational force exerted by Earth (m_Bg)

(ii) Downward force exerted by book A (N_A)

(iii) Upward normal force exerted by book C (N_C)

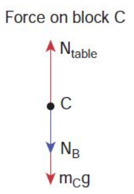


Forces on block C:

(i) Downward gravitational force exerted by Earth (m_Cg)

(ii) Downward force exerted by book B (N_B)

(iii) Upward normal force exerted by the book (N_D)



20) State Newton's third law.

Answer : To every action, there is always an equal (in magnitude) and opposite (in direction) reaction.

21) When walking on ice one should take short steps. Why?

Answer : It is to avoid slipping. Smaller step causes more normal force and thereby more friction.

22) Why are passengers thrown forward from their seats when a speeding bus stops suddenly?

Answer : Inertia of motion: When the bus is in motion, and if the brake is applied suddenly, passengers move forward and hit against the front seat. In this case, the bus comes to a stop, while the body (of a passenger) continues to move forward due to the property of inertia.

23) Give examples for action - reaction forces

Answer : It means that when the object 1 exerts force on the object 2, the object 2 exerts equal and opposite force on the body 1 at the same instant.

(a) Hammer and the nail

(b) Ball bouncing off the wall

(c) Walking on the floor with friction.

24) "Force and motion acts in the same direction". Give example.

Answer : When an apple falls towards the Earth, the direction of motion (direction of velocity) of the apple and that of force are in the same downward direction.

Force and motion in the same direction

25) Give reason "If the object is pressed hard on the surface where it is placed. As a result it is more difficult to move the object".

Answer : If the object is pressed hard on the surface then the normal force acting on the object will increase. As a consequence it is more difficult to move the object.

26) Can you cite a situation where no force acts on a body?

Answer : No. Atleast one force - the force of gravity - must act on the body. One can cite many examples where net forceon the body is zero.

27) A mass of 4kg rests on a horizontal plane, The plane is gradually inclined until at an angle $=15^0$ with the horizontal, the mass just begins to slide. What is the coefficient of static friction between the block and the surface?

Answer : Here θ = 15° is the angle of repose.

∴ Coefficient of friction μ = tan = $\tan 15^0 = 0.27$

28) Calculate the impulse necessary to stop a 1500 kg car moving at a speed of 25 ms^{-1}.

Answer : Use formula I = change in momentum = m(v - u)

(Impulse -37500 Ns)

29) Which law of motion is involved in rocket propulsion?

Answer : Newton's third law of motion.

30) An object of mass 10 kg moving with a velocity of 15 ms^{-1} hits the wall and comes to rest within 0.03 s. Calculate the impulse of the object.

Answer : Initial momentum of an object $p_1 = m \times v = 10 \times 15 = 150\ kgms^{-1}$

Find momentum of an object $p_2 = 0$

∴ Impulse = change in momentum

$$J = \Delta p = p_1 - p_2 = 150 - 0 = 150 Ns$$

∴ J = 150 Ns.