PHYSICS

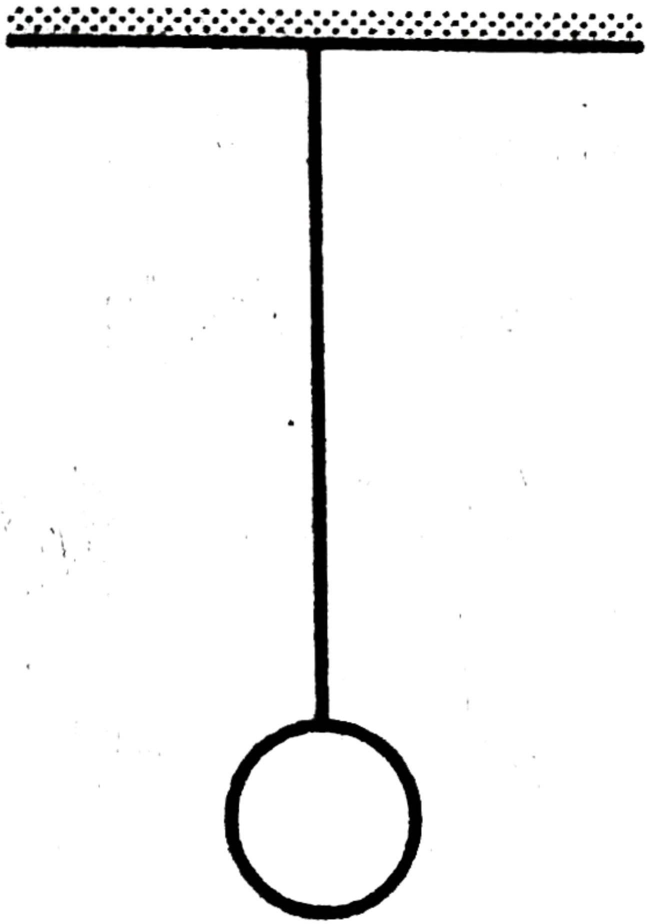
BOOKS - HC VERMA PHYSICS (ENGLISH)

NEWTON'S LAWS OF MOTION

Example

1. A heavy particle of mass 0.50 kg is hanging from a string fixed with the roof. Find the force exerted by the string on the particle.

Take $g = 9.8\frac{m}{s^2}$



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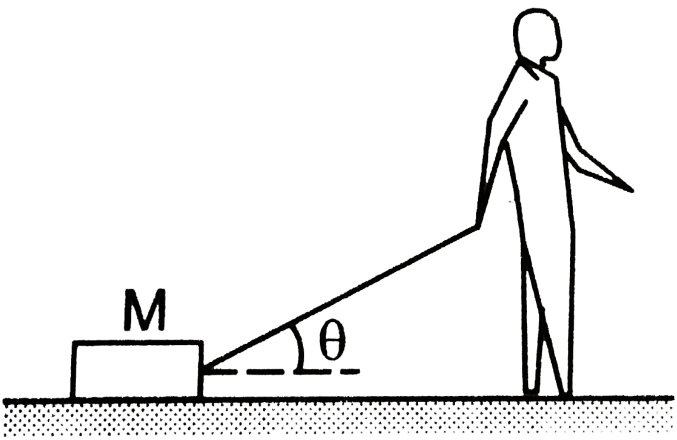
2. A block of mass M is pulled on a smooth horizontal table by a string making an angle θ with the horizontal as shown in figure. If the acceleration of the block is a, find the force applied by the string and by the table N on the block.



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3. The mass of the part of the string below A in figure is m. Find the tension of the string at the lower end and at A.

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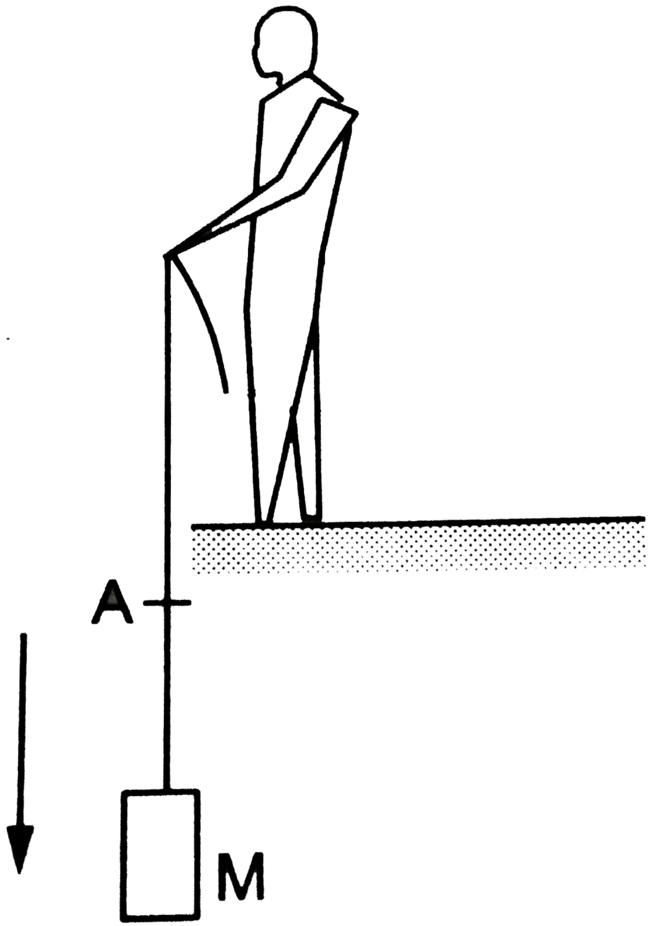
4. The block shown in figure has a mass M and descends with an acceleration a. The mass of the string below the point A is m. Find the tension of the string at the point A and at the lower end.



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5. A pendulum is hanging from the ceiling of a car having an acceleration a_0 with respect to the road. Find the angle made by the string with the vertical.

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Worked Out Examples

1. A body of mass m is suspended by two strings making angles α and β with the horizontal. Find the tensions in the strings.

A.

B.

C.

D.

Answer:

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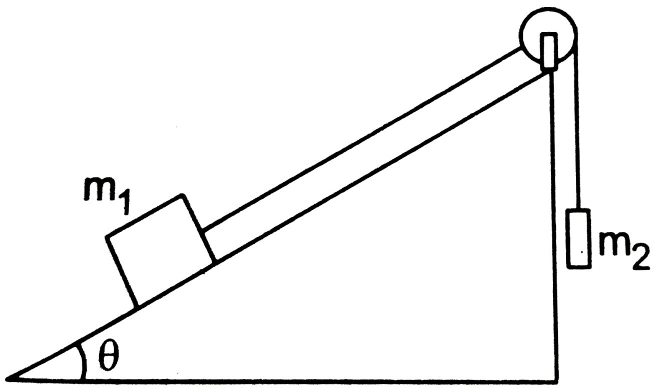
2. Two bodies of masses m_1 and m_2 are connected by a light string going over a smooth lilght pulley at the end of an incline. The $mass_1$ lies on the incline m_2 hangs vertically. The system is t rest. Find the angle of the incline and the fore exerted by the incline on the body of mass `m_1.



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3. A bullet moving at 250 m/s penetrates 5 cm into at tree limb before comign to rest. Assuming that the force exerted by the tree limbis uniform, find its magnitude. Mass of the bulet is 10 g.

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4. The force on a particle of mass 10 g is $\left(\vec{i}\,10+\vec{j}\,5\right)N$. If it starts from rest what would be its position at time `t=5s?

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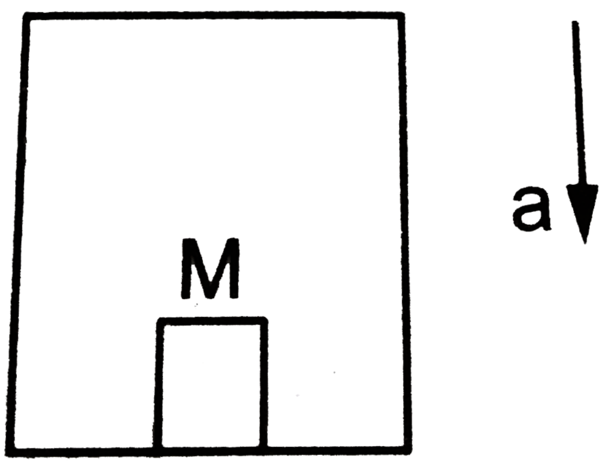
5. With what acceleration a should the box of figure descends so that the block of mass M exerts a force Mg/4 on the floor of the box?



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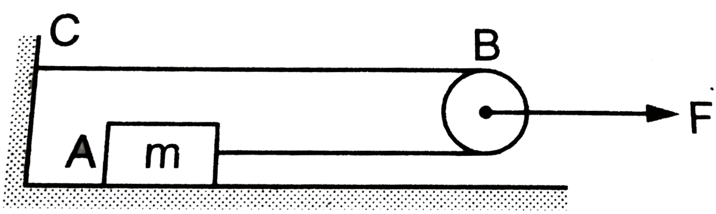
6. A block A of mass m is tied to a fixed point C on a horizontal table through a string passing round a massless smooth pulley B. A force F is applied by the experimenter to the pulley. Show that if the pulley is displaced by a distance x the block will be displaced by 2x. Find the acceleration of the block and the pulley.



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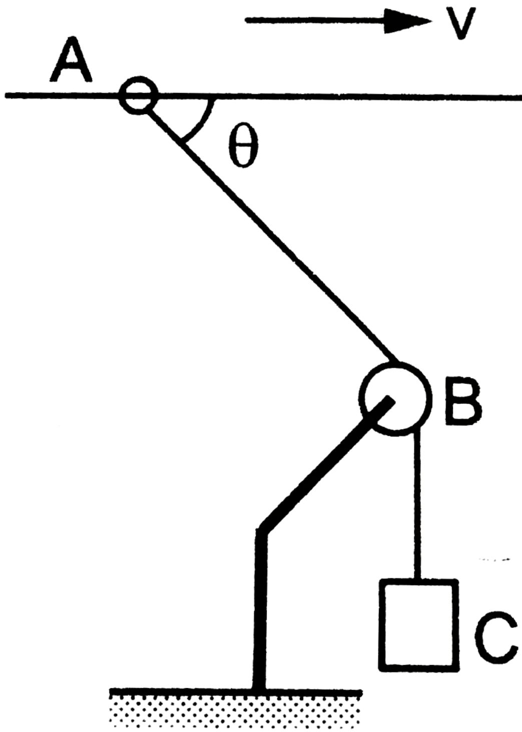
7. A smooth ring A of mass m can slide on a fixed horizontal rod. A string tied to the ring passes over a fixed pulley B and carries a block C of mass $M(=2m)$ as shown in figure. At an instant the string between the ring and the pulley makes an angle θ with the rod. a. Show that, if the ring slides with a speed v, the block descends with speed $v\cos\theta$, b. With what acceleration will the ring starts moving if the

system is released from rest with $\theta = 30^0$



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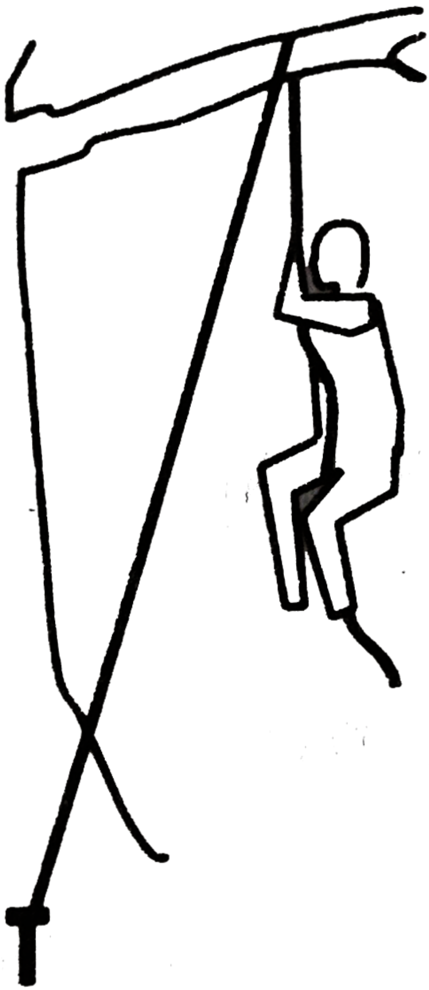
8. A light rope fixed at one end of a wooden clamp on the ground passes over a tree branch and hangs on the other side. It makes an angle of 30^0 with the ground. A man weighing (60 kg) wants to climb up the rope. The wooden clamp can come out of the ground if an upward force greater than 360 N is applied it. Find the maximum acceleration in the upward direction with which the man can climb safely. Neglect friction at the tree branch. Take $g = 10\frac{m}{s^2}$



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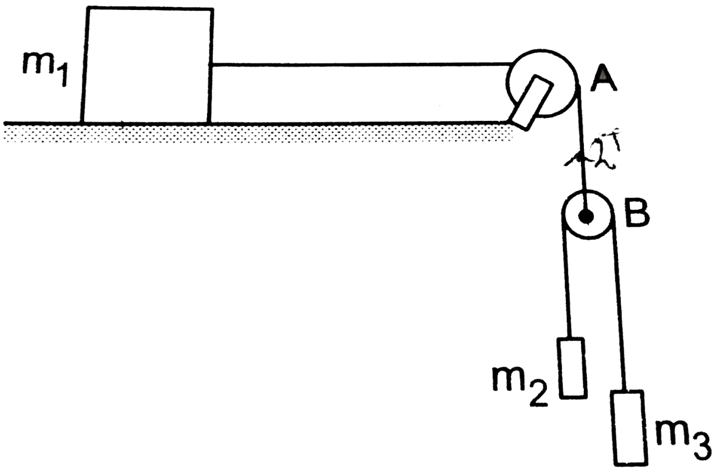
9. Three blocks of masses m_1, m_2 and m_3 are connected as shown in the figure. All the surfaces are frictionless and the string and the pulleys are light. Find the acceleration of m_1



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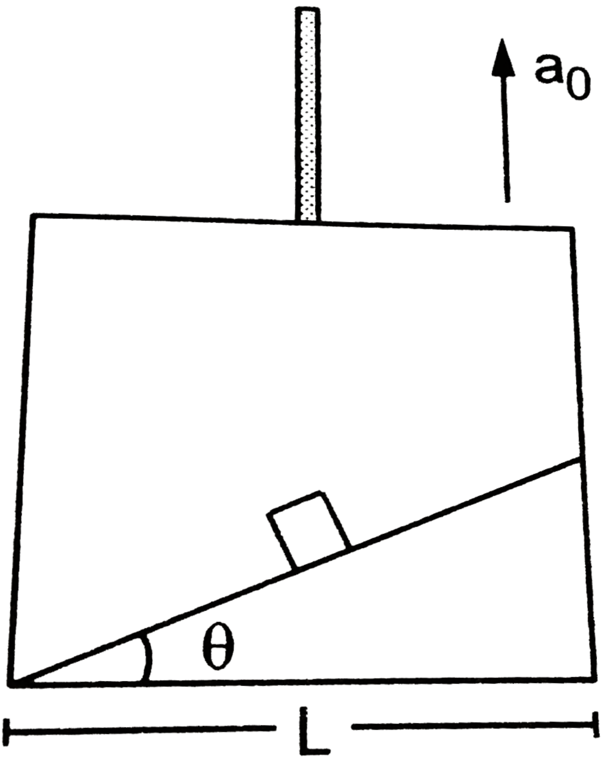
10. A particle slides down a smooth inclined plane of elevation θ fixed in an elevator going up with an acceleration a_0. The base of the incline has a length L. Find the time taken by the particle to reach the bottom.



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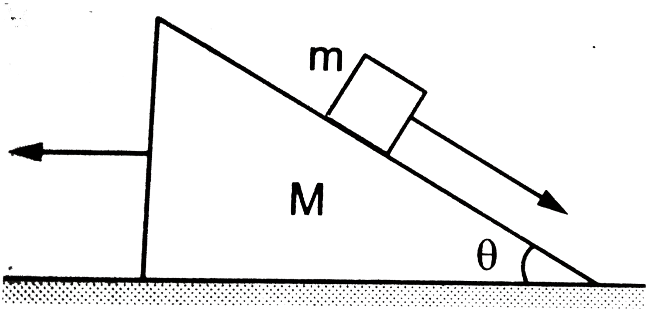
11. All the surfaces shown in figure are assumed to be frictionless. The block of mass m slides on the prism which in turn slides backward on the horizontal surface. Find the acceleration of the smaller block with respect to the prism.



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Objective 1

1. A body of weight w_1 is suspended from the ceiling of a room through as chain of weight w_2. The ceiling pulls the chain by a force

A. w_1

B. w_2

C. $w_1 + w_2$

D. $\frac{w_1 + w_2}{2}$

Answer: C

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2. When a horse pulls a wagon, the force that causes the horse to move forward is the force

A. the cart on the horse

B. the ground on the horse

C. the ground on the cart

D. the horse on the ground

Answer: B

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3. A car accelerates on a horizontal road due to the force exerted by

A. the engine of the car

B. the driver of the car

C. the earth

D. the road

Answer: D

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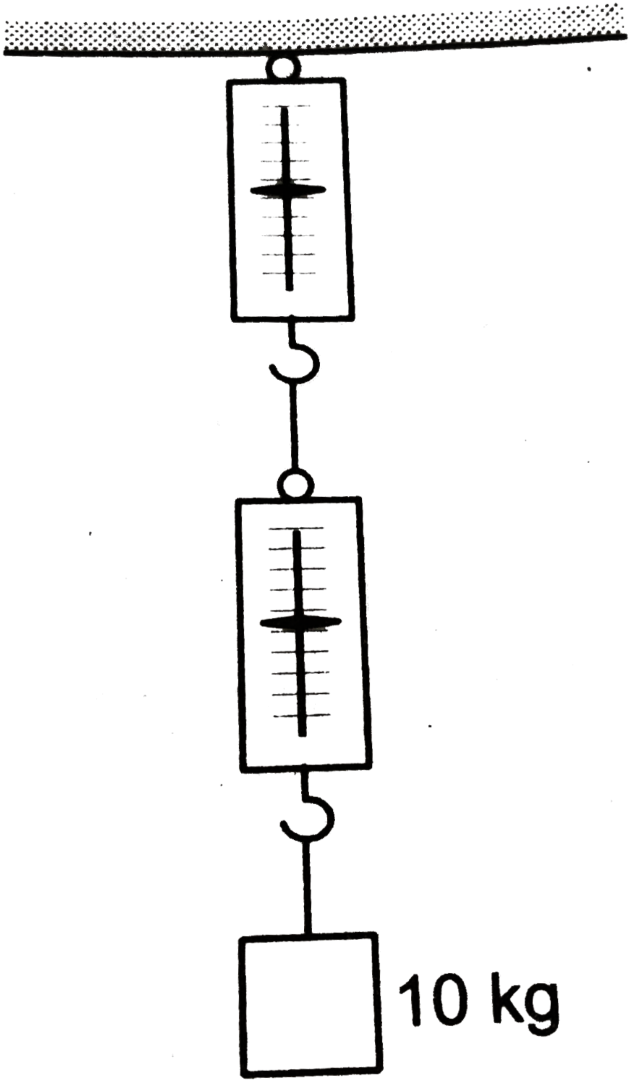
4. A block of mass 10 kg is suspended throug two light spring balances as shown in figure



A. both the scales will read 10 kg

B. both the scales will read 5 kg

C. the upper scale wil read 10 kg and the lower zero

D. the readings may be anything but their sum will be 10 kg

Answer: A

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5. A block of mass m is placed on a smooth inclined plane of inclination θ with the horizontal. The force exerted by the plane on the block has a magnitude

A. mg

B. $m\frac{g}{\cos\theta}$

C. $mg\cos\theta$

D. $mg\tan\theta$

Answer: C

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6. A block of mass m is placed on a smooth wedge of incination θ. The whole system s acelerated horizontally so tht the block does not slip on the wedge. The force exerted by the wedge on the block has a magnitude

A. mg

B. $m\frac{g}{\cos\theta}$

C. $mg\cos\theta$

D. $mg\tan\theta$

Answer: B

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7. Suppose the earth stops rotating about its axis what will be its effect on the weight of a body.

A. fly up

B. slip along the surface

C. fly along a tangent to the earth's surface

D. remain standing

Answer: D

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8. Three rigit rods are joined to form an equilaterla triangle ABC of side 1 m. Three particles carrying charges $20\mu C$ each are attached to the vertices of the triangle. The whole system is at rest in an inertial frame. The resultant force on the charged particle. A has the magnitude.

A. zero

B. 3.6N

C. $3.6\sqrt{3}N$

D. 7.2N

Answer: A

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9. A force F_1 acts on a particle so as to accelerate it from rest to a velocity v. The force F_1 is then replaced by F_2 which decelerates it to rest.

A. F_1 must be equal to F_2

B. F_1 may be equal to F_2

C. F_1 must be unequal to F_2

D. none of these

Answer: B

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10. Two objects A and B are thrown upward simultaeously with the same speed. The mass oif A is greater than the mass of B. Suose the ir exerts a constant and equal force of resitance on the two bodies.

A. The two bodies will rech the same height

B. A will go higher than B.

C. B will go higher than A

D. Any of the above three may happen depending on the speed with which the objects are thrown

Answer: B

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11. A smooth wedge A is fitted in a chamber hanging from a fixed ceiling near the earth's surface.A block B placed at the top of the wedge takes a time T to side down the length of the wedge. If the block is placed at the top of the wedge and the cable supporting the chamber is broken at the same instant, the block will

A. take a time longer than T to slide down the wedge

B. take a time shorter than T to slide down the wedge

C. remain at the top of the wedge

D. jumb off the wedge

Answer: C

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12. In an imaginary atmosphere, the air exerts a small force F on any particle in the direction of the particle's motion. A particle of mass m projected upward takes time t_1 and reaching the maximum height and t_2 in the return journey to the original point. Then

A. $t_1 < t_2$

B. $t_1 > t_2$

C. $t_1 = t_2$

D. the relation between t_1 and t_2 depends n the mass of the particle.

Answer: B

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13. A person standing oin the floor of an elevator drops as coin. The coin reaches the floor of the elevator in a time t_1 if the elevator is stationary and in the t_2 if it is moving uniformly. Then

A. $t_1 = t_2$

B. $t_1 < t_2$

C. $t_1 > t_2$

D. $t_1 < t_2$ or $t_1 > t_2$ depending on whether the lift is going up or down.

Answer: A

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14. A free $\hat{} 238U$ nucleus kept in a train emits an alpha particle. When the train is stationary, a nucleus decays and a passenger measures that the separation between the alpha particle and the recoiling nucleus becomes x at time t after the decay. If the decay takes place while the train is moving at a uniform velocity v, the distance betwen the alpha particle and the recoiling nucleus at a time t after the decay as measured by the passenger is

A. $x + vt$

B. $x - vt$

C. `x

D. depends on the direction of the train.

Answer: C

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Objective 2

1. A refrence frame attached to the earth

A. is an inertial frame by definition

B. cannotbe an inertial frame because the earth is revolving around the sun

C. is an inertial frame because Newton's lawa are applicable in this frame

D. cannot be an inertial drame because the earth is rotating about its axis.

Answer: B::D

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2. A particle stays at rest as seen in a frame. We can concude that :

A. the frame is inertial

B. resultant force on the particle is zero

C. the frame may be inertial but the resultant force on th particle is zero

D. the frame may be noninertial but there is anonero resultant force

Answer: C::D

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3. A particle is found to be at rest when seen from a frame S_1 and moving with a constant velocity when seen from another frame S_2.

Select the possible options :

A. Both the frames re inertial

B. Both the frames are noninertial

C. S_1 is inertial and S_2 is noninertial

D. S_1 is noninertial and S_2 is inertial.

Answer: A::B

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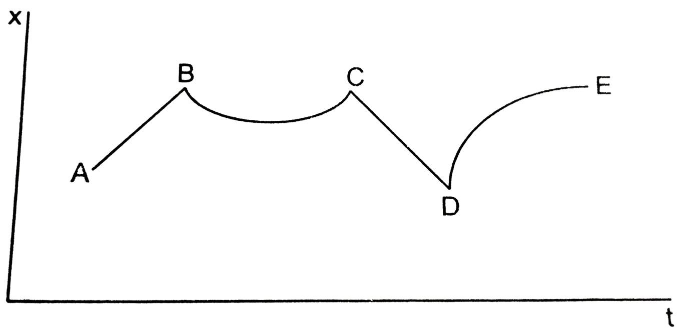
4. Figure shows the displacement of a particle going along the X-axis as a function of time. The force acting on the particle is zero in the region



A. AB

B. BC

C. CD

D. DE

Answer: A::C

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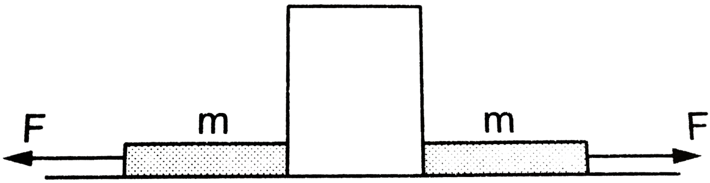
5. Figure shows a heavy block kept on a frictionless surface and being pulled on the left rope is withdrawn but the force on the right end continues to act. Let F_1 and F_2` be the magnitude of the forces by the right rope and the left rope on the block respectively.



A. $F_1 = F_2 = Ff \text{ or } t < 0$

B. $F_1 = F_2 = F + mgf \text{ or } t < 0$

C. $F_1 = F, F_2 = Ff \text{ or } t < 0$

D. $F_1 < F, F_2 = Ff \text{ or } t > 0$

Answer: A

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6. The force exerted by the floor of an elevator on the foot of a person standing there is more than the weight of the person if the elevator is :

A. going up and slowing down

B. going up and slowing down

C. going down and slowing down

D. going down and speeding up

Answer: B::C

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7. If the tension in the cable supporting an elevator is equal to the weight of the elevator, the elevator may be -

(a) going up with increasing speed

(b) going down with increasing speed

(c) going up with uniform speed

(d) going down with uniform speed

A. going up with increasing speed

B. going down with incresing speed

C. going up with uniform speed

D. going down with uniform speed

Answer: C::D

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8. A particle is observed from two frames S_1 and S_2. Lthe frame S_2 moves with respect toS_1 with an acceleration a. Let F_1 and F_2 be the pseudo forces on the particle when seen from S_1 and S_2 respectively. Which of the following are not possible/

A. $F_1 = 0, F_2 \neq 0$

B. $F_1 \neq 0, F_2 = 0$

C. $F_1 \neq 0, F_2 \neq 0$

D. $F_1 = 0, F_2 = 0$

Answer: D

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9. A person says that he mesured the acceleration of a particle to be nonzero while no force was acting on the particle

A. He is a liar

B. His clock ight have run slow

C. His meter scale might have been longer than the standard

D. He migh have used noninertial frame

Answer: D

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Exercises

1. A block of mass 2 kg placed on a long frictionless horizontal table is pulled horizontally by a constant foerce F. It is found to move 10 m in the first two seconds. Find the magnitude of F.

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2. A car moving at 40 km/h is tobe stopped by applyin brakes in the next 4.0 m. If the car weighs 2000 kg, what average force must be applied on it?

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3. In a TV pictgure tubeelectrons re ejected from the cathode with negligible speed and reach a velocity of $5x10^6$ m/s in travelling one centimeter. Assuming straight line motion, find the constant force exerted on the electron. The mass of the electron is 9.1×10^{-31} kg.

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4. A block of mass 0.2 kg is suspended from the ceiling by a light string. A second block of mass 0.3 kg is suspended from the first block through another string. Find the tensions in the two strings. Take $g = 10\frac{m}{s^2}$.

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5. Two blocks of equal mass m are tied to each other through light string. One of the blocks is pulled along the line joining them with a constant force F. Find the tension in the string joining the blocks.

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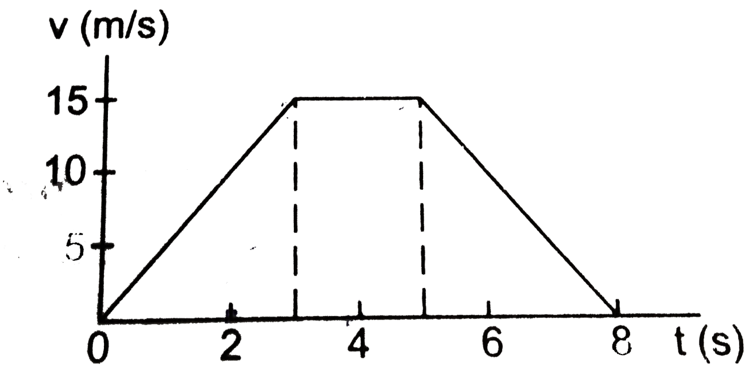
6. A paticle of mass 50 g moves on a straight line. The vatiation of speed with time is shown in figure. Find the force acting on the particle at t=2,4 and 6 secons.



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7. Two blocks A and B of mass m_A and m_B respectively are kept in contact on a frictionless table. The experimenter pushes the block A from behind so that the blocks accelerate. If the block A exerts a fore F on the block B, what is the force exerted by the experimenter on A?

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8. Raindrops of raidus 1mm and mass 4 mg are falling with a speed of 30 m/s on the head of a bald person. The drops splash on the head and come to rest. Assuming equivaletly that the drops cover a distance equal to their radii on the head, estimate the force exerted by the each drop on the head.

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9. Both the springs shown in figure are untretched. If the block is displaced by a distance x and released, what will be the initial acceleration?

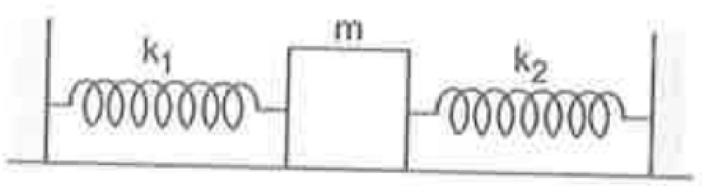

Figure 5-E2

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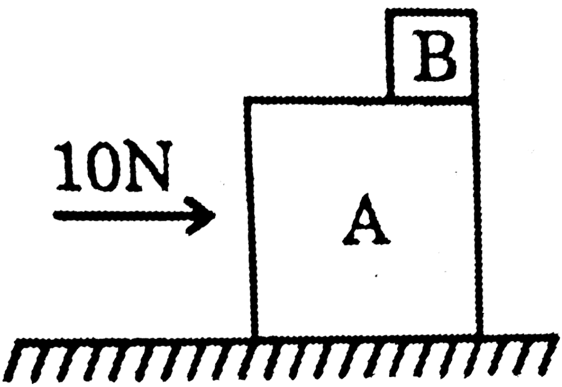
10. A small block B is placed on another block A of mass 5 kg and length 20 cm. Initially, the block B is near the right end of block A. A constant horizontal force of 10 N is applied to the block A. All the surfaces are assumed frictionless. Find the time elapsed before the block B separates from A.



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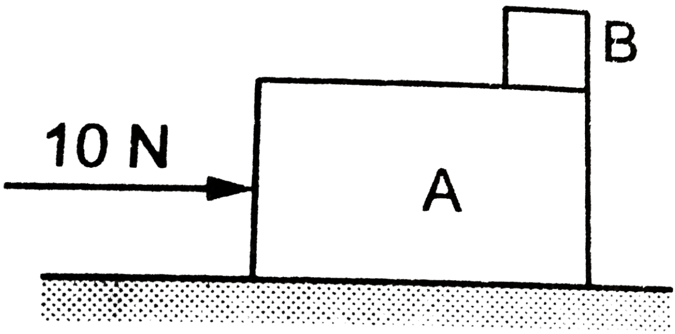
11. A man has fallen into a ditch of width d and two of his friends are slowly pulling him out using a light rope and two fixed pulleys as shown in figure. Show that the force (assumed equal for both the friends) exerted by each friend on the road increases as the man moves up. Find the force when theman is at a depth h.



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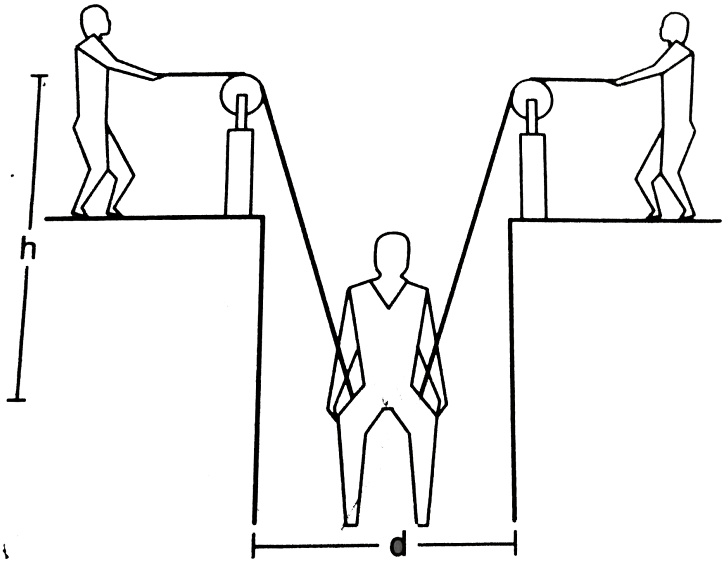
12. The elevator shown in figure is descending with an acceleration of $2\frac{m}{s^2}$. The mass of the block A is 0.5 kg. What force is exerted by the block A on the block B?



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13. A pendulum bobof masss 50 g is suspended from the ceiling of an elevator. Find the tension in the string if the elevator a.

goes up with acceleration $1.2\frac{m}{s^2}$, b. goes up with deceleration $1.2\frac{m}{s^2}$, c. goes up with uniform velocity, d. goes down with acceleration $1.2\frac{m}{s^2}$ e. goes down with deceleration $1.2\frac{m}{s^2}$ and f. goes downwith uniform velocity.

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14. A perso is standing on a weighing machine placed on the floor of an elevator. The elevator starts going up with some acceleratiion, moves with uniform velocity for a while and finally decelerates to stop. The maximum and the minimum weights recorded are 72 kg and 60 kg. Assuming that the magnitudes of the acceleration and the decelaration are teh same., find a. the true weight of the person and b. the magnitude of the acceleration. Take $g = 9.9\frac{m}{s^2}$.

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15. Find the reading of th spring balance shown in figure. The elevator is going up with an accelertion of g/10, the pulley and the strng are light and the pulley is smooth.

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16. A block of 2 kg is suspended from the ceiling through a massless spring of spring constant k=100 N/m. What is the elongation of the spring? If another 1 kg is added to the block, what would be the further elongation?

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17. Suppose the ceiling in the previous problem is that the elevator which is going up with an acceleration of $2.0\frac{m}{s^2}$. Find the elongations.

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18. The force of buoyancy exerted by the atmosphere on a balloon is B in the upward direction and remains constant. The force of air resistance on the balloon acts opposite to the direction of velocity and is proportional to it. The balloon carries a mass M and is found to fall down near the earth's surface with a constant velocity v. How uch mass hsould be removed from teh balloon so that it may rise with a constant velocity v?

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19. An empty plastic box of mass m is found to accelerate up at the rate of g/6 when placed deep inside water. How much sand should be put inside the box so that it may accelerate down at the rate of g/6?

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20. A force $\overrightarrow{F} = \overrightarrow{v} \times \overrightarrow{A}$ is exerted on a particle in addition to the force of gravity, where $\overrightarrow{v}$ is the veocity of the particle and $\overrightarrow{A}$

is a constant vector in the horizontal direction. With what minimum speed a particle of mass m be projected so that it continues to move undeflected with a constant velocity?

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21. In a simple Atwood machine, two unequal masses m_1 and m_2 are connected by string going over a clamped light smooth pulley . In a typical arrangement $m_1 = 300g$ and $m_2 = 600g$. The system is released from rest.

(a). Find the distance traveled by the first block in the first two seconds. (b). Find the tension in the string. (c). Find the force exerted by the clamp on the pulley.

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22. In a simple Atwood machine, two unequal masses m_1 and m_2 are connected by string going over a clamped light smooth pulley . In a typical arrangement $m_1 = 300g$ and

$m_2 = 600g$. The system is released from rest. (a) Find the distance travelled by the first block in first two seconds. (b) Find the tension in the string. (c) Find the force exerted by clamp on the pulley.

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23. Figure shows a uniform rod of length 30 cm having a mass of 3.0 kg. The strings shown in the figure are pulled by constant forces of 20 N and 32N. Find the force exerted by the 20 cm part of the rod on the 10 cm part. All the surfaces are smooth and the strings and the pulleys are light.

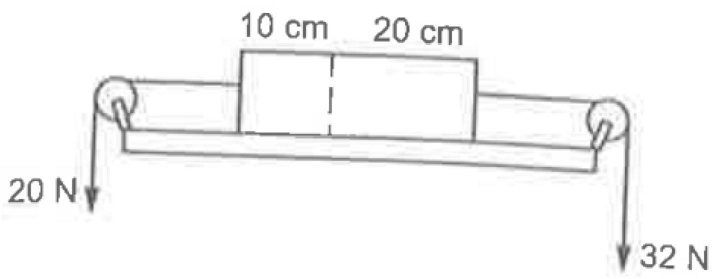

Figure 5-E8

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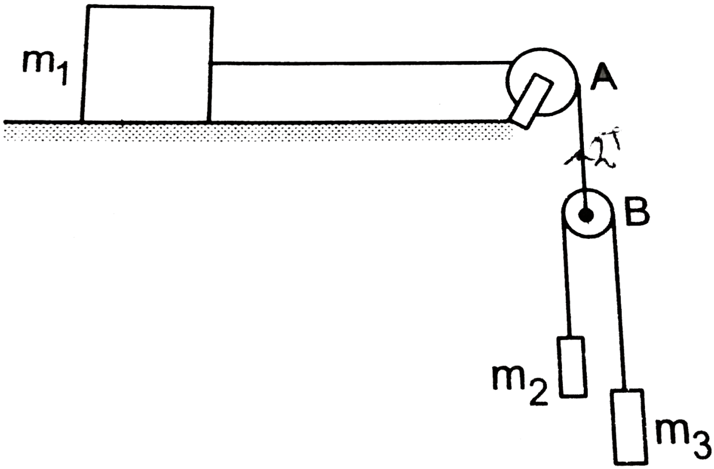
24. Three blocks of masses m_1, m_2 and m_3 are connected as shown in the figure. All the surfaces are frictionless and the string and the pulleys are light. Find the acceleration of m_1



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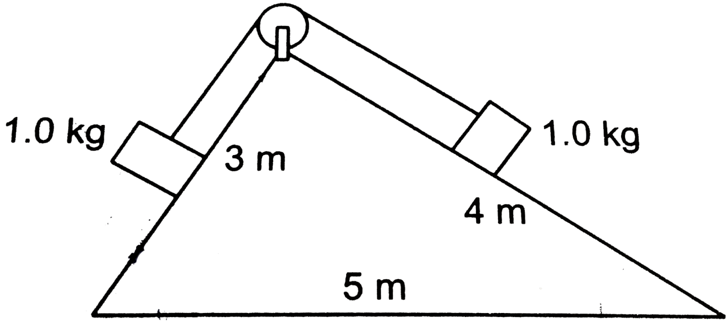
25. A constant force $F = m_2 \frac{g}{s}$ is applied on the block of mass m_1 as shown in figure. The string and the pulley are light and the surface of the table is smooth. Find the acceleration of

m_1



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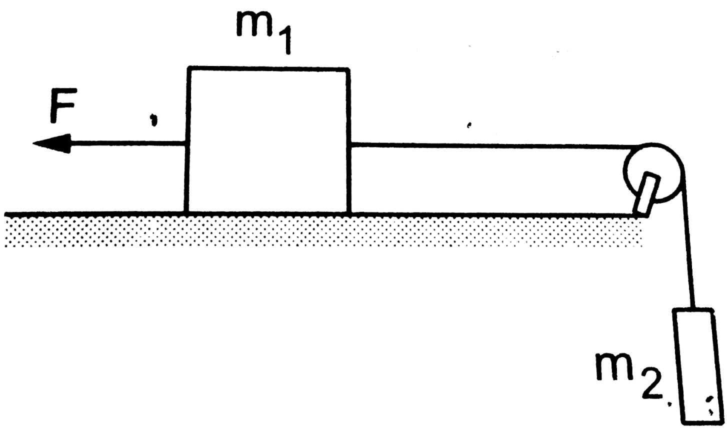
26. In figure $m_1 = 5kg, m_2 = 2kg$ and $F = 1N$. Find the acceleration of either block. Describe the motion of m_1 if the string breaks but F continues to act.



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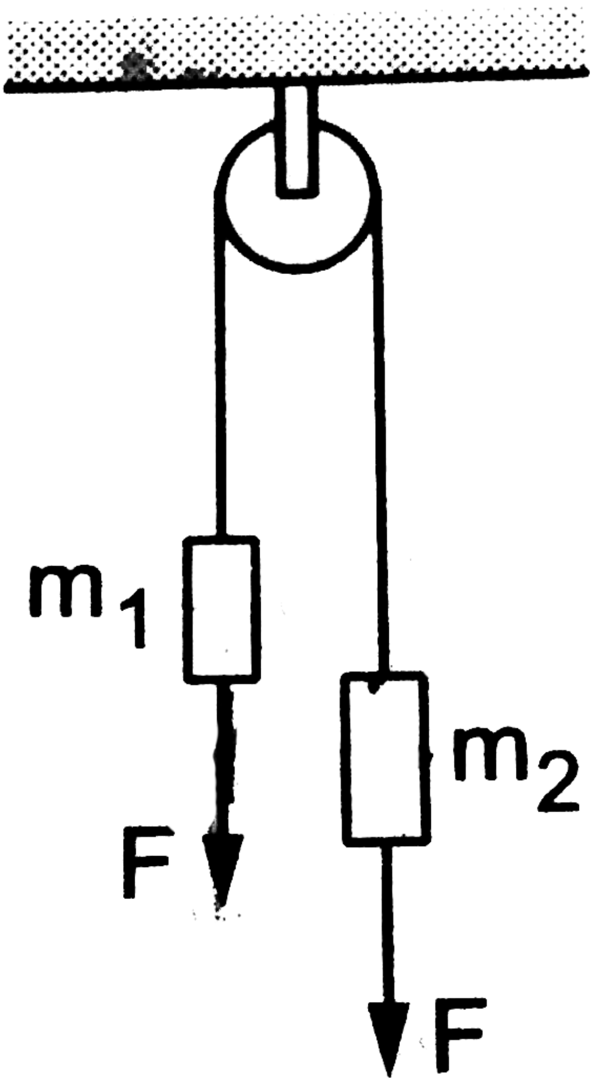
27. Let $m_1 = 1kg, m_2 = 2kg$ and $m_3 = 3kg$ is figure. Find the acceleration of m_1, m_2 and m_3. The string from the upper pulley to m_1 is 20 cm when the system is released from rest. How long will it take before m_1 strikes the pulley?



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28. In the previous problem, suppose $m_2 = 2.0kg$ and $m_3 = 3.0kg$. What should be the mass m so that it remains at rest?

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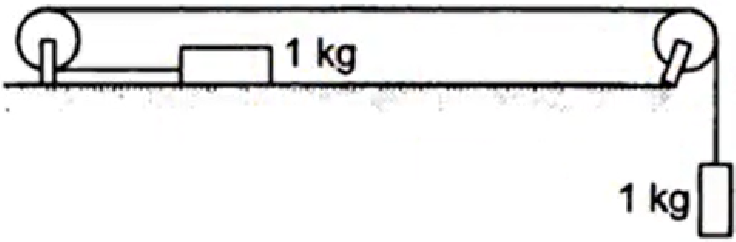
29. Calculate the tension in the string shown in figure. The pulley and the string are light and all surfaces are frictionless. Take g=10 m/

s^2.



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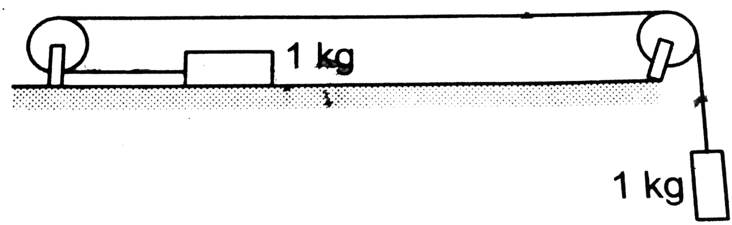
30. Consider4 the situation shown in figure. Bothe the pulleys and the string are light and all the surfaces are friction less. a. Find the acceleration of the mass M. b. Find the tension in the string c. Calculate the force exerted by the clamp on the pulley A in the figure.



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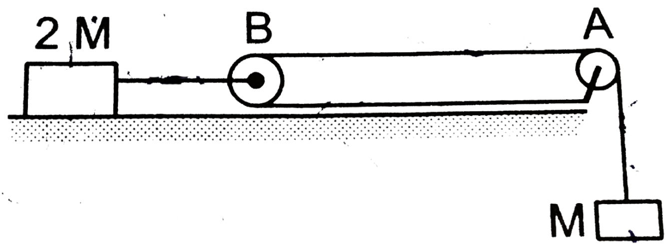
31. find the acceleration of the block of mass M in the situation shown in figure. All the surfaces are frictionless and the pulleys and the string are light.



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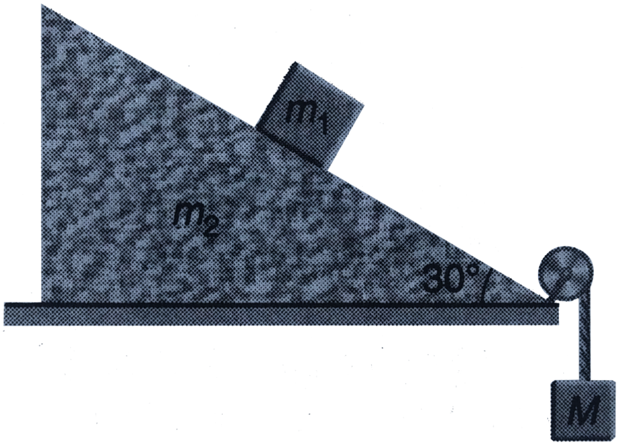
32. In figure $m_1 = 1kg$ and $m_2 = 4kg$ Find the mass m of the hanging block which will prevent the smaller block from slipping over the triangular block .All the surface are frictionless and the string and the pulleys are light



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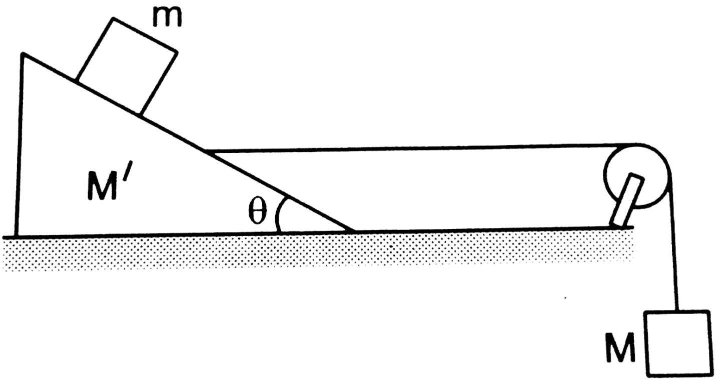
33. Find the acceleration of the blocks A and B in the this situations shown in figure.



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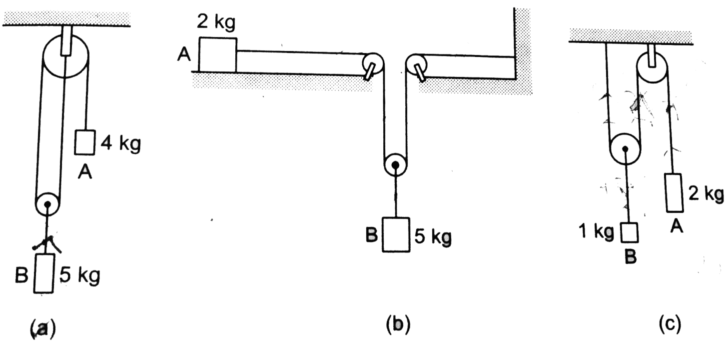
34. Find the acceleration of the 500 g block in figure.



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35. A monkey a mass 15 kg is climbing on a rope with one end fixed to the ceiling. If it whishes to go up with an acceleration of $1\frac{m}{s^2}$, how much force should it apply to the rope? If the rope is 5 m long and the monkey starts from rest, how much time will it take to reach the ceiling?

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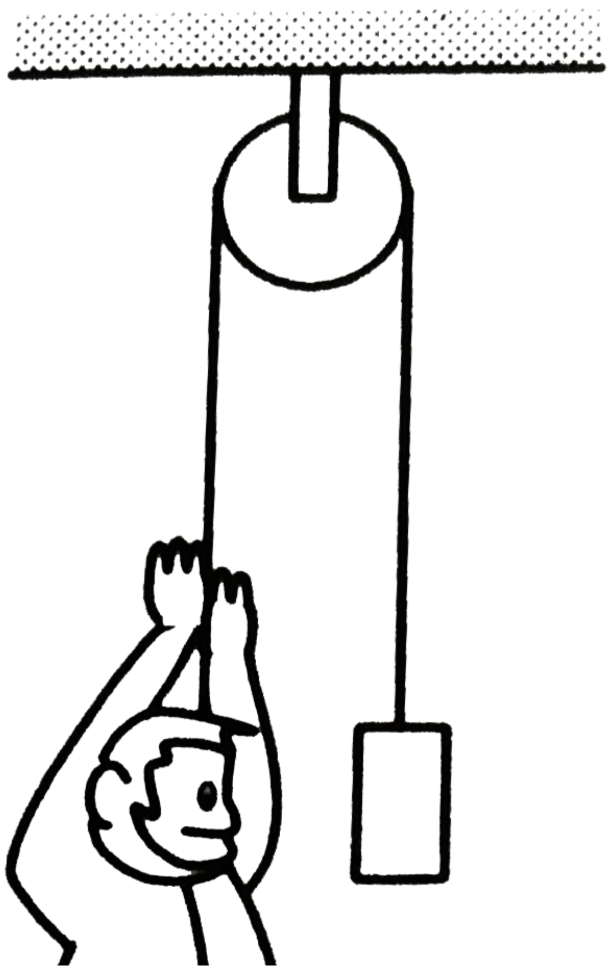
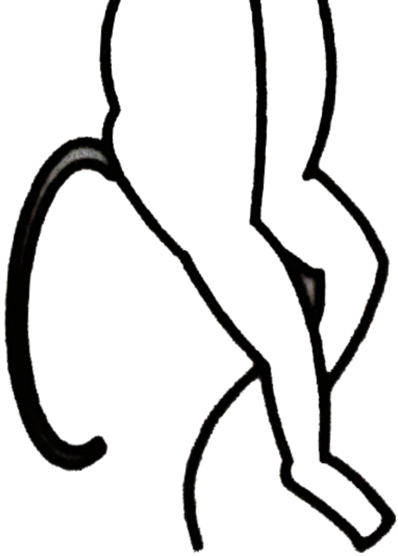
36. A Monkey is Climbing on a Rope that Goes Over a Smooth Light Pulley and Supports a Block of Equal Mass at the Other End in the Following





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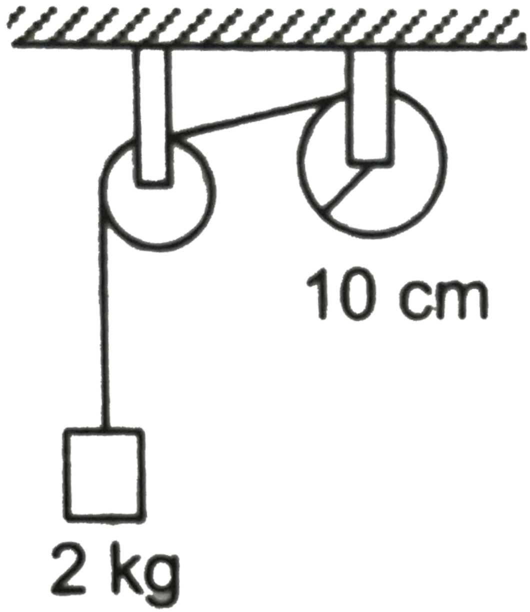
37. A string is wrapped on a wheel of moment of inertia 0.20 kg-m^2 and radius 10 cm and goes through a light pulley to support a block of mass 2.0 kg as shown in figure. Find the

acceleration of the block.



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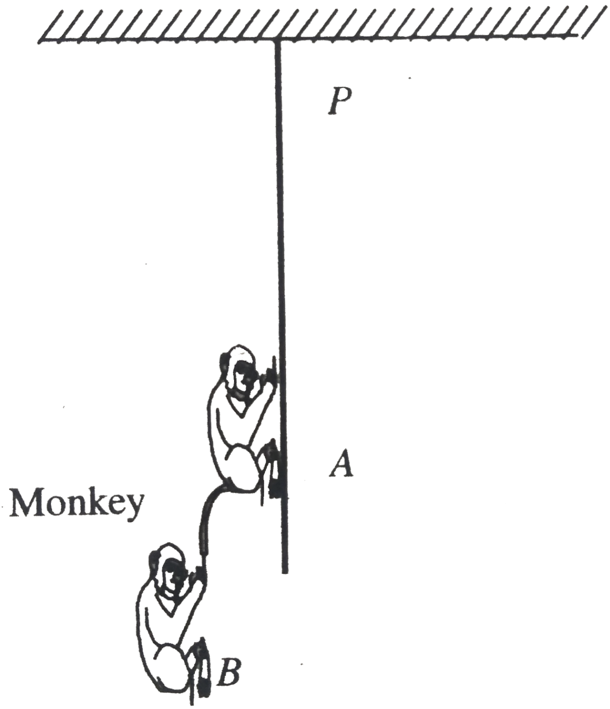
38. A monkey A (mass = 5 kg) is climbing up a rope tied to a rigid support. The monkey B (mass=2kg) is holding on the tail of monkey A. If the tail can tolerate a maximum tension of 30N, what maximum force should monkey A apply on the rope in order to carry monkey B with it? $(g = 10 ms^{-1})$



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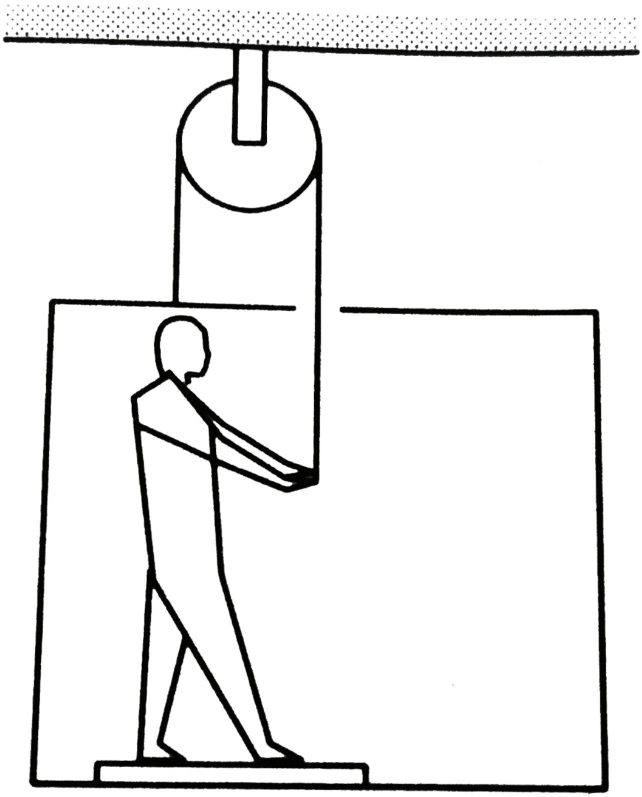
39. Figure shows a man of mass 60 kg standing on a light weighting machine kept in a box of mass 30 kg. The box is hanging from a pulley fixed to the ceiling through a light rope, the other end of which is held by the man himself. If the man manages to keep the box at rest, what is the weight shown by the machine? What force should he exert on the rope to get his correct weight on the machine?



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40. A block A can slide on a frictionless incline of angle θ and length l, kept inside an elevator going up with uniform velocity v. Find the time taken by the block to slide down the length of the incline if it is released from the top of the incline.

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41. A car is speeding up on a horizontal road with anaccelerationa. Consider the following situations in the car. i. A ball is suspended from the ceiling through a string and is maintaining a constant angel with the vertical. Find this angle. Ii. A block is kept on a smooth incline and does not slip on the incline. Find the angle of the incline with a horizontal.

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42. a block is kept on the floor of an elevator at rest. The elevator starts descending with an acceleration of $12\frac{m}{s^2}$. Find the displacement of the block during the first 0.2 s after the start. Take $g = 10\frac{m}{s^2}$.

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Questions For Short Answer

1. The apparent weight of an object increases in an elevator while accelerating upward. A moongphaliwala sells his moongphali usinga beam balance in an elevator. Will he gain more if the elevator is accelerating up?

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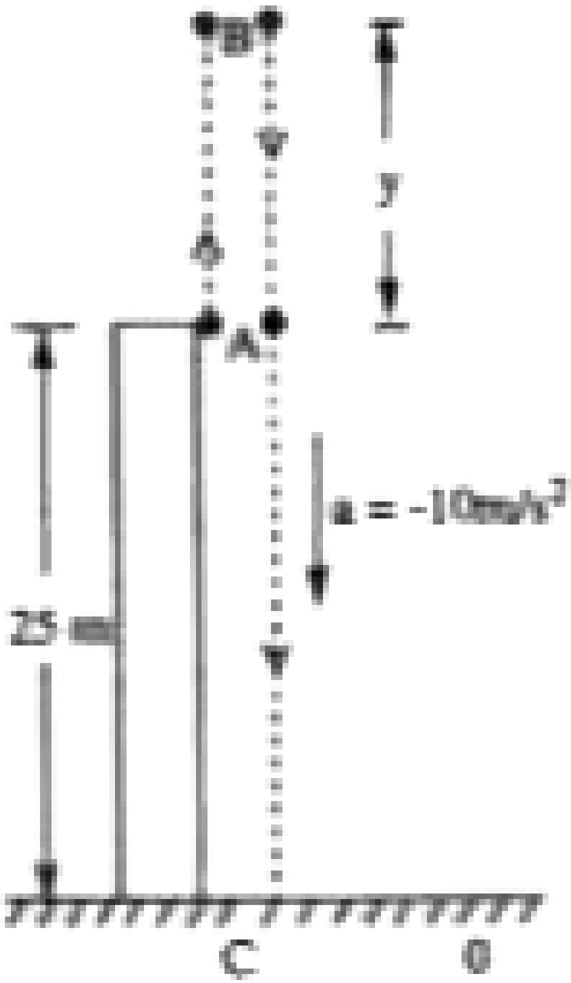
2. A ball is thrown vertically upwards with a velocity of $20ms^{-1}$ from the top of a multistorey building. The height of the point from where the ball is thrown is 25.0 m from the ground. (a) How high will the ball rise ? and (b) how long will it be before the ball hits the ground? Take $g = 10ms^{-2}$



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3. A person sitting on a open car movie at constant velocity throwns a ball vertically up into air . The ball fall

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4. Is it possible for a particle to describe a curved path if no force acts on it? Does your answer depend on the frame of ereference chosen to view the particle?

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5. You are travelling in a car during a thunderstorm. In order to protect yourself from lightning, you should prefer to

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6. It is sometimes heard that inertial frame of reference is only an ideal concept and no such inertial frame actually exists. Comment.

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7. An object is placed far away from all theobjects that can exert force on it. A frame of reference is constructed by taking the origin and axes fixed in this object. Will the fraame be necessarily inertial?

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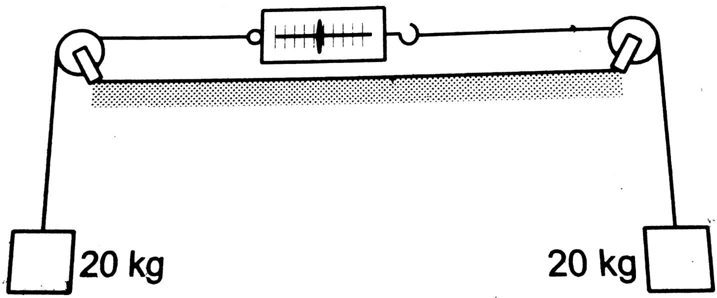
8. Figure shows a light spring balance connected to two blocks of mass 20 kg each. The graduations in the balance measure the tension in the spring. A. What is the reading of the balance? B. Will the reading change if the balance is heavy, say 2.0 kg? c. What will happen if the spring is light but the blocks have unequal masses?



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9. The acceleration of a particle is zero as measured from an inertial frame of reference.

Can we conclude that no force acts on the particle?

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10. Suppose you are running fast in a field when you suddenly find a snake in front of you. You stip quickly. Which force is responsible for your deceleration?

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11. If you jump barefooted on a hard surface, your legs get injured. But they are not injured if you jump on a soft surface like sand or pillow. Explain.

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12. According to Newton's third law each team pulls the opposite team with equal force in a tug of war. Why then one team wins aned the other loses?

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13. A spy jumps from an airplane with his pasrachute. The spy accelerates downward for some time when the parachute opens. The acceleration is sudenly checked and the spy slowly falls on the ground. Explain the action of parachute in checking the acceleration.

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14. Consider a book lying on a table. The weight of the book and the nromal force by the table on the book are equal in magnitude and opposite in direction. Is this an example of Newton's third law?

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15. Two blocks of unequal masses are tied by a spring. The blocks are pulled stretching the spring slightly and the system is released on a frictionless horizontal platform. Are the forces due to the spring on the two blocks equal and opposite. If yes, is it can example of Newton's third law?

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16. When a train starts, the head of a standing passenger seems to be pushed backward. Analyze the situation from the ground frame. Does it really go backward? Coming back to the train frame, how do you explain the backward movement of the head on the basis of Newton's laws?

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17. A plumb bob is hung from the ceiling of a train compartment. If the train moves with an acceleration a along a straight horizontal track, the string supporting the bob makes an angle $\tan^{1}\left(\frac{a}{g}\right)$ with the normal to the ceiling. Suppose the train moves on an inclined straight track with uniform velocity, if the angle of incline is $\tan^{-1}\left(\frac{a}{g}\right)$, the string again makes the same angle with the normal to the ceiling. Can a person sitting inside the compartment tell by looking at the plumb line whether the train is accelerated on a horizontal straight track or it is going on an incline? If yes, how? If no, suggest a method to do so.

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