PHYSICS

BOOKS - DHANPAT RAI & CO PHYSICS (HINGLISH)

LAWS OF MOTION : FRICTION

Example

1. Give the magnitude and direction of the force acting on a stone of mass 0.1 kg (a) just

after it is dropped from the window of a stationary train

(b) just after it is dropped from the window of a train running at a constant velocity of $36km/hr$

(c) just after it is dropped from the window of a train accelerating with $1ms^{-2}$

(d) lying on the floor of a train which is accelerating with $1ms^{-2}$ the stone being at rest relative to the train .

Neglect the resistance of air throughout .

2. A pebble of mass 0.05 kg is thrown vertically upwards Give the magnitude and direction of net force on the pebble (a) during its upward motion (b) during its downward motion (c) at the highest point where it is momentarily rest Do your answers change if the pebble were thrown at an angle of say $45°$ horizontal direction Ignore air resistance .

3. An army vehicle of mass 1000 kg is moving with a velocity of $10m/s$ and is acted upon by a forward force of 1000 N due to the engine and a retarding force of 500 N due to friction. What will be its velocity after 10 s

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4. A constant retarding force of 50 N is applied to a body of mass 20 kg moving initially with a

speed of $15ms^{-1}$ How long does the body take to stop ?

5. A constant force acting on a body of mass $3kg$ changes its speed from $2ms^{-1}$ to $3.5ms^{-1}$ in 25 s. The direction of motion of the body remains unchanged . Calculte magnitutude and direction of the force .

6. A bullet of mass 40g moving with a speed of $90ms^{-1}$ enters a heavy wooden block and is stopped after a direction of 60cm. The average resistive force exered by the block on the bullet is

7. A force of 72 dyne is inclined to the horizontal at an angle of $60°$. Find the acceleration in a mass of 9 g, which moves in a horizontal direction.

8. A body of mass 5 kg is acted upon by two perpendicular forces 8 N and 6 N Give the magnitude and direction of the acceleration of the body .

9. The driver of a three wheeler moving with a speed of $36km/h$ sees a child standing in the

middle of the road and brings his vehicle to rest in 4 s just in time to save the child What is the average retarding force on the vehicle ? The mass of three wheeler is 400 kg and mass of the driver is 65 kg .

10. A car starts from rest and accelerates uniformly with $2 \ ms^{-2}$. At t = 10 s, a stone is dropped out of the window 1 m high of the car. What are the (i) velocity, and (ii)

acceleration of the stone at t = 10.1 s? (Neglect air resistance). Take g = $9.8ms^{-2}$.

11. A body of mass 0 .40 kg moving initially with a constant speed of $10m/s$ to the north is subjected to a constant force of 8.0 N directed towards the south for 30 s Take the instant the force is applied to be t = 0 , and the position of the particle at that time to be x

$=$ 0 , predict its position at $t = -5s, 25s, 100s$?

12. A stream of water flowing horizontal with a speed of $15ms^{-1}$ gushes out of tube of cross sectional area $10^{-2}m^2$ and hits at a vertical wall nearby . What is the force exerted by the impact of water, assuming that water rebounds with the same speed.

13. A balloon has a mass of 10 gram in air. The air escapes from the balloon at a unifrom rate with a velocity of $5cm/s$ and the balloon shrinks completely in 2.5 s . Calculate the average force acting on the balloon.

14. A body of mass m moves along X-axis such that its position co-ordiante at any instant t is $x = at^4 - bt^3 + ct$, where a, b and c are

constants. What is the force acting on the particle at any instant t?

15. A ball of mass 0.1 kg is thrown against a wall. It strikes the wall normally with a velocity of 30 ms^{-1} and rebounds with a velocity of 20 ms^{-1}. Calculate the impulse of the force exerted by the wall.

16. A cricket ball of mass 150 g moving with a velocity of 15 ms^{-1} is brought to rest by a player in 0.05 s. Calculate the impulse and the average force exerted by the player.

17. A hammer weighing 1 kg moving with the speed of $10ms^{-1}$ strikes the head of a nail driving it 10 cm into a wall. Neglecting the mass of the nail, calculate (i) the acceleration

during impact (ii) the time interval of the impact and (iii) the impulse.

18. Two billiard balls each of mass 0 .05 kg moving in opposite directions with speed $6ms^{-1}$ collide and rebound with the same speed What is the impulse imparted to each ball due to the other ?

19. A glass ball whose mass is 10 g falls from a height of 40 m and rebounds to a height of 10 m. Find the impulse and the average force between the glass ball and the floor if the time during which they are in contact is 0.1 s.

20. While lauching a rocket of mass $2 \times 10^4 kg$ a force of $5 \times 10^5 N$ is applied for $20s$ Calculate the velocity attained by the rocket at the end of $20s$.

21. A machine gun fires a bullet of mass 40 g with a velocity $1200 ms^{-1}$. The man holding it can exert a maximum force of 144 N on the gun. How many bullets can be fire per second at the most?

22. A ball moving with a momentum of $5kgms^{-1}$ strikes against a wall at an angle of $45°$ and is reflected at the same angle Calculate the impulse .

23. A batsman deflects a ball by an angle of $45°$ without changing its initial speed which is equal to $54kmH^{-1}$ What is the impulse

imparted to the ball ? Mass of the ball is 0.05 kg

24. Fig. shows the position-time graph of a particle of mass 4 kg. What is the (i) force acting on the particle for $t < 0, t < 4s, 0 < t < 4s$? (ii) impulse at t = 0 and t = 4 s? Assume that the motion is one dimensional.

**25.** Figure shows the position-time graph of a particle of mass $0.04kg$. Suggest a suitable physical context for this motion. What is the time between two consecutive impulses received by the particle? What is the magnitude of each impluse?
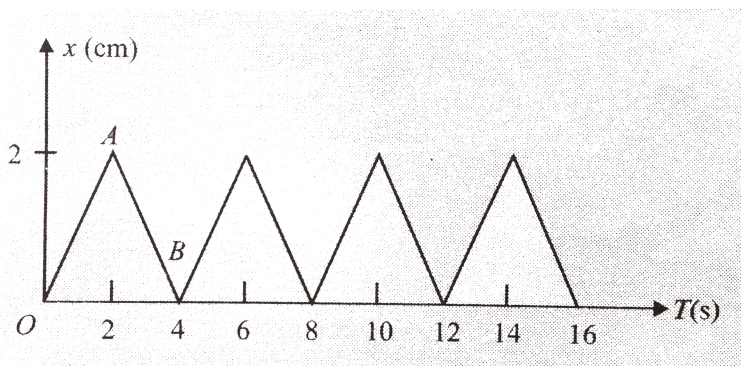
26. The initial speed of a body of mass $2kg$ is $5ms^{-1}$ A force acts for 4 seconds in the direction of motion of the body. The force time graph is shown in Calculate impulse of the force and also find the speed of the body .
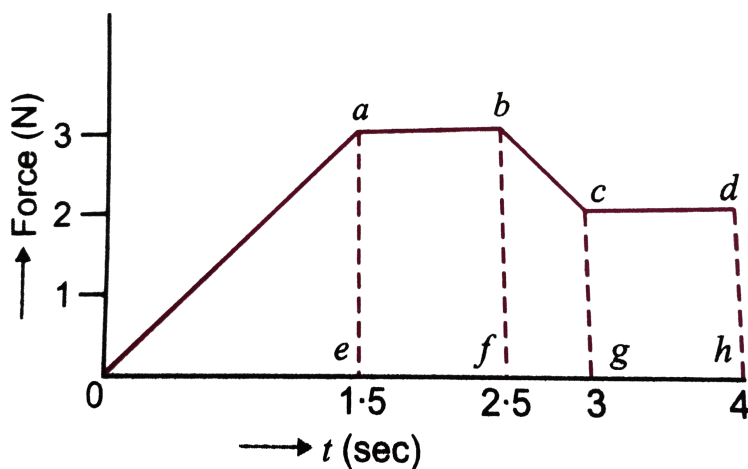
27. Ten one-rupee coins are put on top each other on a table. Each coin has a mass m. The rection of the 6th coin (counted from the bottom) on the 7th coin is

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28. An elevator weighs $4000kg$ When the upward tension in the supporting cable is $48000N$ what is the upward acceleration? Starting from rest, how far does it rise in 3 seconds ?

29. A man of mass 70 kg stands on a weighing machine in a lift , which is moving (a) upwards with a unifrom speed of $10ms^{-1}$ (b) downwards with a unifrom acceleration of $5ms^{-2}$

(c) upwards with a unifrom acceleration of $5ms^{-2}$ What would be th readings on the scale in each case ?

(d) What would be the reading if the lift

machanism failed and it hurtled down freely under gravity ?

30. A block of mass 25 kg is raised by a 50kg man in two different ways as shown in fig. what is the action on the floor by the man in the two cases? If the floor yields to a normal force of $700N$, which mode should the man adopt to lift the block without the floor

yielding?

(a)   (b)

25 kg   25 kg
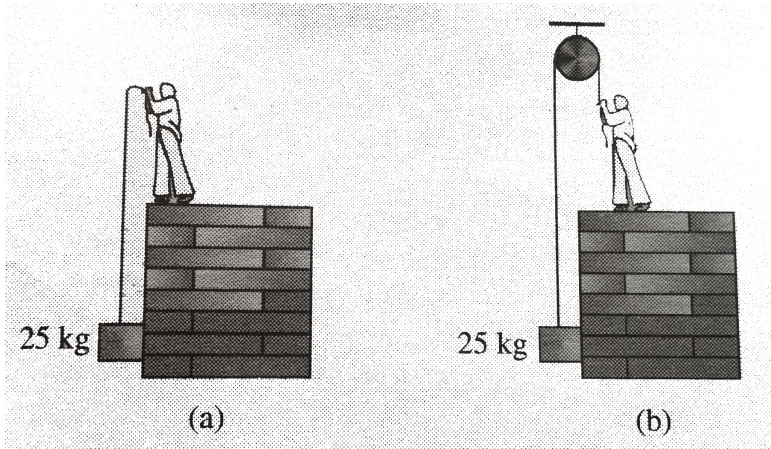
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31. A monkey of mass 40 kg climbs on a rope

which can withstand a maximum tesion of 600

N In which of the following cases will the rope

break ? The monkey

(a) climbs up with an acceleration of $6ms^{-2}$

(b) climbs down with an acceleration of $4ms^{-2}$

(c) climbs up with a unifrom speed of $5ms^{-1}$

(d) falls down the rope nearly freely under gravity Ignore the mass of the rope .

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32. A helicopter of mass 2000 kg rises with a vertical acceleration of $15ms^{-2}$. The total mass of the crew and passengers is 500 kg.

Give the magnitude and direction of the (g $= 10ms^{-2}$)

(a) Force on the floor of the helicopter by the crew and passengers.

(b) action of the rotor of the helicopter on the surrounding air.

(c) force on the helicopter dur to the surrounding air.

33. A lift of mass 2000 kg is supported by thick steel ropes . If maximum upward acceleration of the lift be $1.2 m/s^2$, and the breaking stress for the ropes be

$2.8 \times 10^8 Nm^{-2}$

what should be the minimum diameter of rope ?

34. A shell of mass 200g is fired by a gun of mass 100kg. If the muzzle speed of the shell is $80ms^{-1}$, then the rcoil speed of the gun is

35. A 30 kg shell is flying at 48 ms^{-1}. When it explodes, its one part of 18 kg stops, while the remaining part flies on. Find the velocity of the later.

36. A nucleus is at rest in the laboratory frame of reference Show that if it distintegrates into two smaller nuclei the products must be emitted in opposite directions .

37. A neutron having a mass of $1.67 \times 10^{-27} kg$ and moving at $10^8 m/s$ collides with a deuteron at rest and sticks to it. If the mass of the deuteron is

$3.33 \times 10^{-27} kg$ then the speed of the combination is

38. A car of mass 1000 kg travelling at $32ms^{-1}$ dashes into the rear of a truck of mass 8000 kg , moving in the same direction with a velocity of $4ms^{-1}$ After the collision the car bounces with a velocity of $8ms^{-1}$ What is the velocity of the truck after the impact ?

39. A hunter has a machine gun that can fire 50 g bullets with a velocity of $150 m/s$. A 60 kg tiger springs at him with a velocity of $10 ms^{-1}$ How many bullets must the hunter fire per secoud into the tiger in order to stop him in his track.

40. A machine gun has a mass of 10 kg . It fires 30 gram bullets at the rate of 6 bullets per

second with a speed of $400m/s$. What force must be to the gun to keep it in position ?

41. A body of mass $1kg$, initially at rest, explodes and breaks into three fragments of masses in the ratio $1:1:3$. The two pieces of equal mass fly off perpendicular to each other with a speed of $30m/s$ each. What is the velocity of the heavier fragment?

42. A rocket with a lift off mass 20000 kg is blasted upwards with a net initial acceleration of $5ms^{-2}$ Calculate the initial thrust (force) of the blast.

43. Fuel is consumed at the rats of $100kg/s$ in a rocket The exhaust gases are ejected at a speed of $4.5 \times 10^4 ms^{-1}$ w.r.t the rocket What is the thrust experienced by the rocket Also

calculate velocity of the rocket at the instant when its mass is reduced to m/10 of rocket .

44. A rocket of initial mass $6000kg$ ejects mass at a constant rate of $16kg/s$ with constant relative speed of $11m/s$ What is the acceleration of the rocket one mnute after blast ?

45. The mass of a rocket is 500 kg and the relative velocity of the gases ejecting from it is 250 m/s with respect to the rocket. The rate of burning of the fuel in order to give the rocket an initial acceleration $20m/s^2$ in the vertically upward direction $g = 10\dfrac{m}{s^2}$, will be -

46. A rocket is set for vertical firing If the exhaust speed is $1200ms^{-1}$, how much gas must be ejected per second to supply the

thrust needed (i) to overcome the weight of rocket (ii) to give to the rocket an initial vertical upward acceleration of $29.6 m/s^2$ Given mass of rocket = 6000 kg.

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47. If the maximum possible exhaust velocity of a rocket be $2 km/s$ calculate the ratio m_0/m for it to acquire a veocity of $11.2 km/s$ after starting from rest .

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48. A rocket motor consumes 100 kg of fuel per second, exhausting it with a speed of $5 \times 10^3 ms^{-1}$. (i) What force is exerted on the rocket ? (ii) What will be the velocity of the rocket at the instant its mass is reduced $(1/20)$th of its initial mass, its initial velocity being zero. Neglect gravity.

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49. A rocket is going upward with acceleration motion. A man string in it feels his weight increased 5 time his own weight. If the mass of the rocket including that of the man is $1.0 \times 10^4 kg$, how much force is being applied by rocket engine? $\left(Take g = 10ms^{-2}\right)$.

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50. A balloon with mass m is descending down with an acceleration a (where $a < g$). How

much mass should be removed from it so that

it starts moving up with an acceleration a?

51. A mass of 6 kg is suspended by a rope of length 2 m from the ceilling A force of 50 N in the horizontal direction is applied at the mid - point P of the rope as shown . What is the angle the rope makes with the vertical in equilibrium ? (Take = $10ms^{-2}$) . Neglect mass of the rope .

52. Determine the tension T_1 and T_2 in the strings shown in Fig.

53. A train is moving along a horizontal track . A pendulum suspended from the roof makes an angle of $4°$ with the vertical . If

$g = 10m/s^2$, what is the acceleration of the train ?

54. A ball of mass $1kg$ hangs in equilibrium from two strings OA and OB as show in figure. What are the tensions in strings OA and OB? $(Takeg = 10m/s^2)$

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

56. A horizontal uniform rope of length L, resting on a frictionless horizontal surface, is pulled at one end by force F. What is the tension in the rope at a distance l from the end where the force is applied?

57. A pull of 15 N is applied to a rope attached to a block of mass 7 kg lying on a smooth horizontal surface. The mass of the rope is 0.5 kg. What is the force exerted by the block on the rope?

58. A horizontal force of 500 N pulls two masses 10 kg and 20 kg (lying on a frictionless

table) connected by a light string. What is the tension in the string ? Does the answer depend on which mass end the pull is applied?

59. Two blocks of masses m_1 and m_2 in contact lie on a horizontal smooth surface as shown in The blocks are pushed by a force F If the two blocks are always in contact what is the force at their common interface

60. As shown in Fig. three blocks connected together lie on a horizontal frictionless table and pulled to the right with a force F = 50 N. If $m_1 = 5kg$, $m_2 = 10kg$ and $m_3 = 15kg$, find the tensions T_1 and T_2.
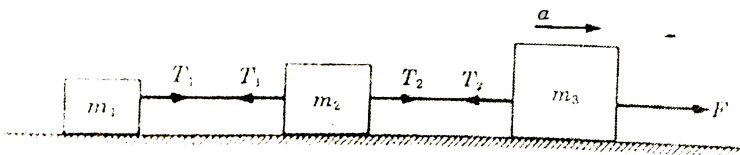
61. Two masses M and m are connected at the two ends of an inextensible string. The string passes over a smooth frictionless pulley. Calculate the acceleration of the masses and the tension in the string. Given $M > m$.

62. Two masses 7 kg and 12 kg are connected at the two ends of a light inetensible string that goes over a frictionless pulley. Find the

acceleration of the masses and the tension in the string when the masses are released.

63. Two bodies of masses $11kg$ and $11.5kg$ are connected by a long light string passing over a smooth pulley Calculate velocity and height ascended/descended by each body at the end of $4s$.

64. The masses $m_1 m_2$ and m_3 of the three bodies shown in fig . Are 5 , 2 and 3 kg respectively Calculate the valuse of tension $T_1 T_2$ and T_3 when (i) the whole system is going upward with an acceleration of $2m/s^2$ (ii) the

whole system is stationary $\left(g = 9.8m/s^2\right)$.
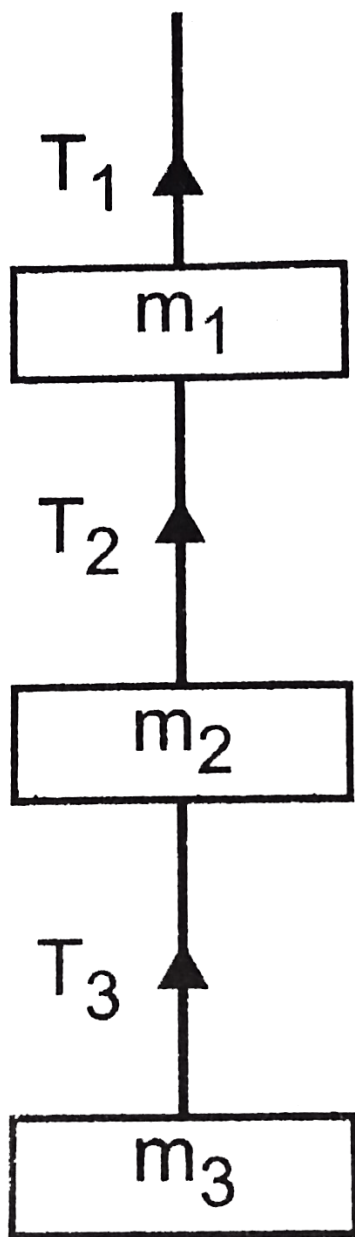
65. A body m_1 of mass 10 kg is placed on a smooth horizontal table It is connected to a string which passes over a frictionless pulley and carries at the other end , a body m_2 of mass 5 kg What acceleration will be produced in the bodies when the nail fixed on the table is removed ? what will be the tension in the string during the motion of the bodies ? What when the bodies stop ? (g= 9.8 N ? kg) .

66. A block of mass 100 kg is set into motion on a frictionless horizontal surface with the help of a frictionless pulley and rope system shown in What horizontal force should be applied on the rope to produce an acceleration of $0.1 m/s^2$
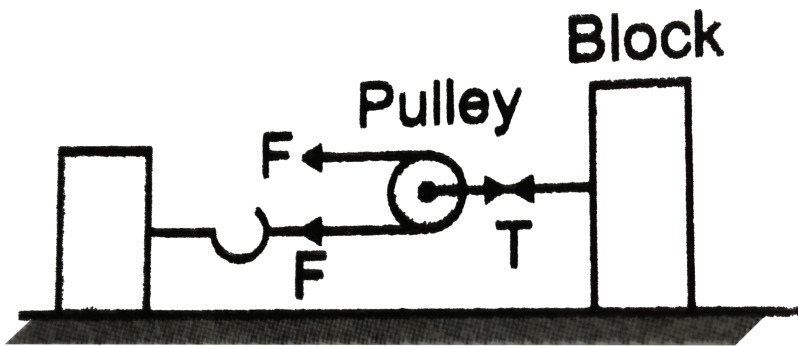
67. In terms of masses m_1, m_2 and g, find the acceleration of both the blocks shown in Fig. Neglect all friction and masses of the pulley.

68. Two particles each of mass m are connected by a light string of length $2L$ as shown in the figure. A constant force F is applied continuoulsly at the mid $-$ point of the string at right $-$ angle to intial position of the string. Find the acceleration of each particle and the

acceleration of approach between the particles when separation between them is $2x$
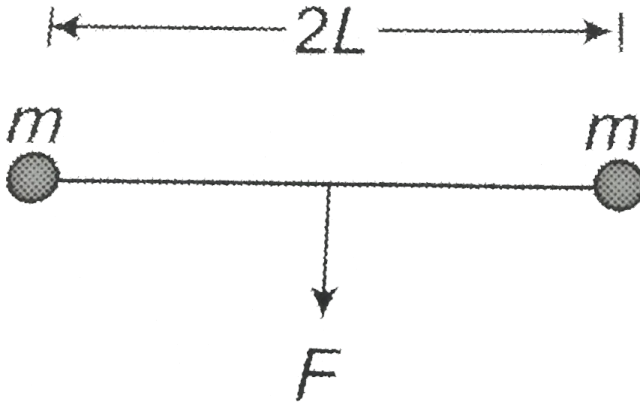
69. Two blocks of masses 50 kg and 30 kg connected by a massless string pass over a light frictionless pulley and rest on two smooth

planes inclined at angles $30°$ and $60°$ resp . With horizontal .Determine the accelertion in the two blocks and tension in the string $g = 10m/s^2$.
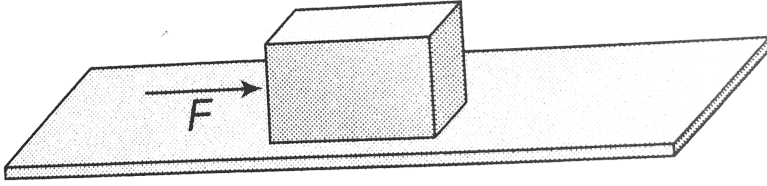
70. A block of mass $2kg$ is kept on the floor. The coefficient of static friction is 0.4 . If a force F of $2.5N$ is applied on the block as shown in the figure, the frictional force between the block and

the floor will be.

71. A block of weight 20 N is placed on a horizontal table and a tension T is applied on the block . Tension can be increased to 8 N before the block begins to slide . A force of 4 N keeps the block moving at constant speed , once

it has been set in motion . Find the coefficients of static friction and kinetic friction].

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72. A force of 49 N is just sufficient to pull a block of wood weighing 10 kg on a rough horizontal surface. Calculate the coefficient of friction and angle of friction.

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73. A cubical block rests on an inclined plance of $\mu = \dfrac{1}{\sqrt{3}}$. Determine the angle at which the block just slides down the incline .
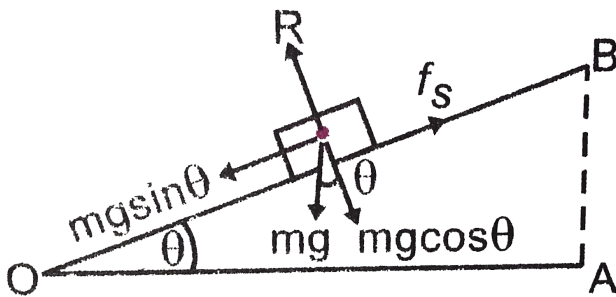
74. A body rolled on ice with a velocity of $8ms^{-1}$ comes to rest after travelling a distance of 4 m . Calculate the coefficient of friction .

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

76. The coefficient of friction between the ground and the wheels of a car between the ground and the wheels of acar moving on a horizontal road is 0.5 If the car starts from rest , what is the minimum distance in which it can acquire a speed of $72km/h$? take $g = 10ms^{-2}$.

77. A horizontal force of $1.2kg$ is applied on a $1.5kg$ block , which rests on a horizontal surface

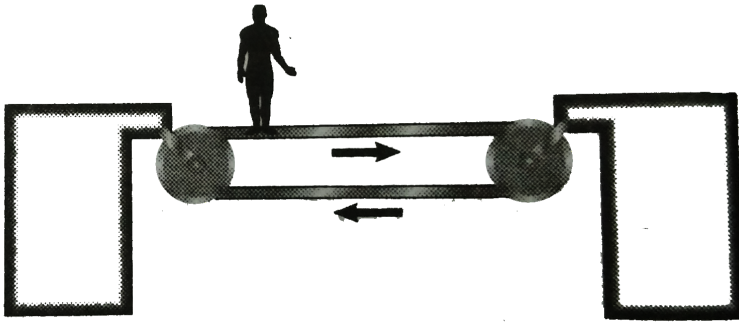If the coefficient of friction is 0.3 find the acceleration produced in the block .

78. A bullet of mass 0.01 kg is fired horizontal into a 4 kg wooden block block at rest , on a horizontal surface. The coefficient of kinetic friction between the block and bullet is 0.25 the combination moves 20 m before coming to rest . With what speed did the bullet strike the block ?

79. Figure shown a man standing stationary with respect to a horizontal converyor belt that is accelerationg with $1m/s^{-2}$. What is the net force on the man?If the coefficient of ststic friction between the man's shoes and the belt is 0.2 upto what maximum acceleration of the belt can the man continue to be stationary relative to the belt? Mass of the man

$$= 65kg\left(g = 9.8m/s^2\right)$$

80. A block of mass 15 kg is placed on a long trolly . The coefficient of friction between the block and trolly is 0.18 The trolly accelerates from rest at $0.5m/s^2$ for 20 seconds and then moves

with a unifrom velocity Discuss the motion of the block as viewed by (i) a stationary observer on the ground (ii) an observer moving with the trolly .

81. The rear side of a truck is open and a box of 40 kg mass is placed 5 m from the open end The coefficient of friction between the box and the surface below it is 0.15 On a straight road the truck starts from rest and accelerates with
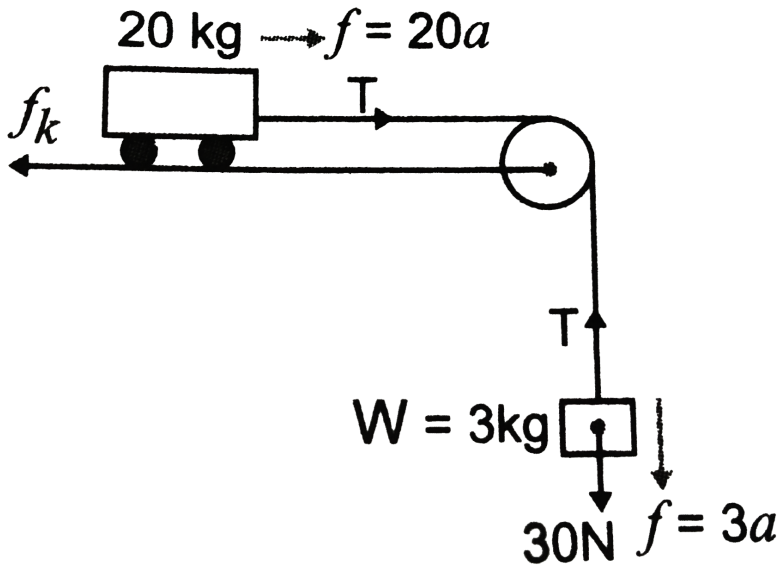
$2m/s^2$ At what distance from the starting point does the box fall off the truck ? Ignore the size of the box .

82. What is the acceleration of the block and trolley system shown in if the coefficient of kinetic friction between the trolley and the surface is 0 .04 ? What is the tension in the string ? Take $g = 10ms^{-2}$ Neglect the mass of

the string

20 kg $\longrightarrow f = 20a$

f_k

T

T

W = 3kg

30N $f = 3a$

83. A block A of mass 4 kg is placed on another

block B of mass 5 kg , and the block B rests on a

smooth horizontal table . For sliding block A on

B , a horizontal force of 12 N is required to be applied on A How much maximum force can be applied on B so that both A and B move togrther ? Also find out acceleration produced by this force .

84. Two bodies A and B of mass 5 kg and 10 kg contact with each other rest on a table against a rigid The coefficient of friction between the bodies and the table is 0.05 A force of 200 N is

applied horizontal on A What are (a) the reaction of thee wall (b) the the action , reaction forces between A & B ? What happens when the wall is removed ? Does the answer to (b) Change , when the bodies are in motion ? Ignore differnce between μ_s and μ_k

A   B
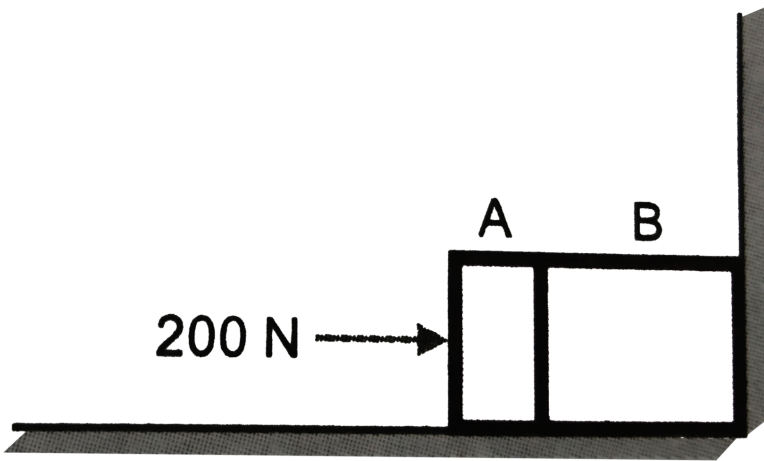
200 N ------→

85. A 50 metric ton train has to run at 72 kmh^{-1} . If the track is level and total resistance is $\dfrac{1}{80}$ th the weight of the train, find the power of the engine.

86. An engine of 100 H.P draws a train of mass 200 metric ton with a velocity of $36km/h$. Find the coefficient of friction .

87. A box of mass 4 kg is placed on a wooden plank of length 1.5m which is lying on the ground. The plank is lifted from one end along its length so that it becomes inclined. It is noted that when the vertical height of the top end of the plank from the ground becomes 0.5m, the box begins to slide. Find the coefficient of friction between the box and the plank.

88. A mass of 200 kg is placed on a rough inclined plane of angle $30°$. If coefficient of limiting friction is $1/\sqrt{3}$, find the least forces in newton , acting parallel to the plane (i) to keep the mass from sliding down (ii) to move the mass up the plane.

89. A box of mass $4kg$ rests upon an inclined plane This inclination is gradually incresed till

the box starts sliding down the plane. At this stage slope of the plane is 1 in 3 Find coefficient of friction between the box and the plane What force applied to the box parallel to the plane will just make the box move up the plane ?

90. A block of metal of mass 50 gram placed over an inclined plane at an angle of $15°$ slides down without acceleration . If the inclination is

increased by $15°$, what would be the acceleration of the block ?

91. A block is gently placed at the top of an inclined plane 6.4 m long . Find the time taken by the block to slide down to the bottom of the plane . The plane makes an angle$30°$ with the horizontal Coefficient of friction between the block and the plane is 0.2 Take $g = 10m/s^2$.

92. When an automobile moving with a speed of $36km/h$ reaches an upward inclined road of angle $30°$, its engine is switched off. If the coefficient of friction is 0.1, how much distance will the automobile move before coming to rest ? Take $g = 10ms^{-2}$.

93. Starting from rest , a body slides down at $45°$ inclined plane in twice the time it takes to slide

down the same distance in the absence of friction. The coefficient of friction between the body and the inclined plane is

94. A block of mass 2 kg rests on an inclined plane which makes an angle of $30°$ with the horizontal. The coefficient of friction between the block and the surfcae is $\sqrt{3/2}$. (i) What force should be applied on the block so that it moves down without any acceleration ? (ii) What

force should be applied on the block so that it moves up without any acceleration ? (iii) Calculate the ratio of the powers in the above two cases if the block moves with uniform speed in both the cases.

95. Find the force required to move a train of 2000 quintals up an incline of 1 in 50 , with an acceleration of $2ms^{-2}$, the force of friction being 0.5 newton per quintal .

96. An engine of weight 6.5 metric ton is going up an inclined plane of 5 in 13 at the rate of $9km/h$. If the coefficient of friction is $\dfrac{1}{120}$. Calculate the power of the engine. Take $g = 9.8m/s^2$

97. A body starts rolling down an inclined plane , the top half is rough . Find the ratio of the force

of friction and weight of the body if the body is brought to rest just when it reaches the bottom , the angle of the plane being $30°$.

98. A body of mass m is released from the top of a rough inclined plane of length l and height h If f is the force of friction prove that the body will reach the bottom with a velocity $v = \sqrt{\dfrac{2}{m}(mgh - fl)}$.

99. Calculate the height upto which an insect can crawl up a fixed bowl in the form of a hemisphere of radius r. Given coefficient of friction is $1/\sqrt{3}$.

100. Two blocks of mass 2 kg and 5 kg are connected by an ideal string passing over a pulley. The block of mass 2 kg is free to slide on a surface inclined at an angle of $30°$ with the

horizontal whereas 5 kg block hangs freely. Find the acceleration of the system and the tension in the string. Given $\mu = 0.30$.

101. A truck tows a trailor of mass $1200kg$ at a speed of $10m/s$ on a level road The tension in the coupling is $1000N$

(i) What is power expended on the trailor ?

(ii) Find tension in the coupling when the truck accends a road having an inclination of 1 in 6

Assume that the frictional resistance of the incline is same as that on the level road .

102. A $4m$ long ladder weighing $25kg$ rests with its upper end against a smooth wall and lower end on rough ground.What should be the minimum coefficient of friction between the ground and the ladder for it to be inclined at $60°$ with the horizontal without slipping? $(Takeg = 10m/s^2)$

Problems

1. A block of metal weighing $2kg$ is resting on a frictionless plane . It is struck by a jet of releasing water at the rate of $1kgs^{-1}$ and at a speed of $5ms^{-1}$ Calculate the intial acceleration of the blocks .

2. A satellite in a force - free space sweeps stationary interplanetary dust at a rate $dM/dt = \alpha v$, where M is the mass , v is the velocity of the satellite and α is a constant. What is the deacceleration of the satellite ?

3. Two bodies A and B each of mass m are fixed together by a massless spring . A force F acts on the mass B as shown in fig .3 (a)18. At the instant

shown , the body A has an acceleration a What is the acceleration of B ?

4. An elevator and its load wiegh a total of 1600 lb. Find the tension T in the supporting cable when the elevator, originally moving downwards at 20 ft/s is brought to rest with constant acceleration in a distance of 50 ft.

5. Two blocks of mass 2.9 kg and 1.9 kg are suspended from a rigid support S by two inextensible wires each of length 1 meter, see fig. The upper wire has negligible mass and the lower wire has a uniform mass of $0.2kg/m$. The whole system of blocks wires and support have an upward acceleration of $0.2m/s^2$. Acceleration due to gravity is $9.8m/s^2$.
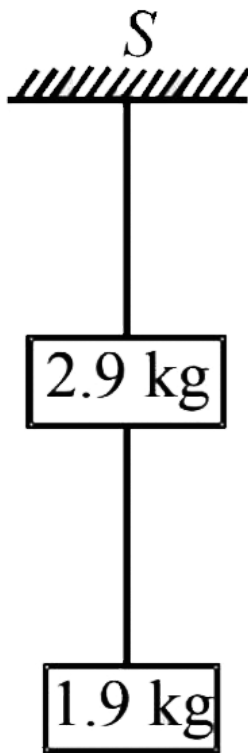
(i) Find the tension at the mid-point of the lower wire.

(ii) Find the tension at the mid-point of the upper wire.

6. A uniform rope of mass m per unit length, hangs vertically from a support so that the lower end just touches the table top shown in figure. If it is released, show that at the time a length y of the rope has fallen, the force on the table is equivalent to the weight of the length $3y$ of the

rope.
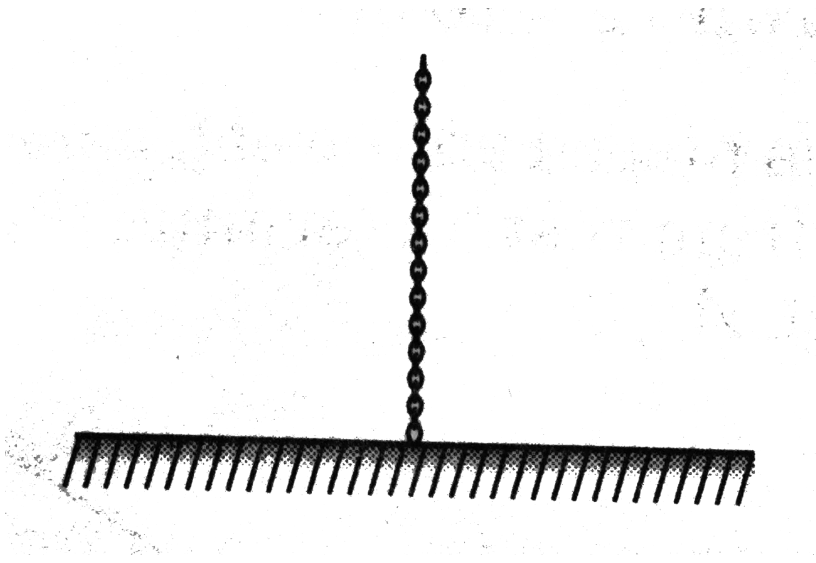
7. A dise of mass 10 g is kept floating horizontally by throwing 10 marbles per secound against it from below . If mass of each marble is 5 g
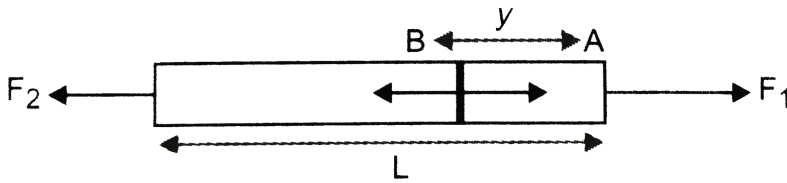
Calculate the velocity with which marbles are striking the disc . Assume that marbles strike the disc . Normally and rebound downwards with the same speed.

8. What is the tension in a rod of length length L and mass M at a distance y fromF_1 when the rod is acted on by two unequal force F_1 and

$F_2(< F_1)$ as shown in.

9. An explosion blows a rock into three pieces

Two pieces whose masses are 200 kg and 100 kg

go off at $90°$ to eachother with a velocity of

$8m/s$ and $12m/s$ respectively If the third piece

flies off with a velocity of$25m/s$ then calculate

the mass of this piece and indicate the direction

of flight of this piece in a diagram.
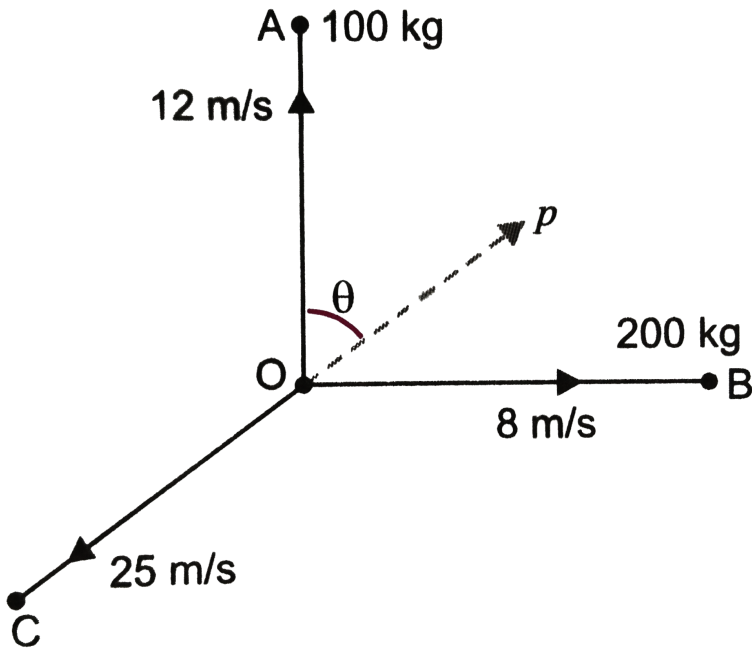
10. A $20g$ bullet pierces through a plate of mass $M_1 = 1kg$ and then comes to rest inside a

second plate of mass $M_2 = 2.98kg$ as shown in Fig. It is found that the two plates, initially at rest, now move with equal velocities. Find the percentage loss in the initial velocity of the bullet when it is between M_1 and M_2. Neglect any loss of material of the plates due to the action of bullet.
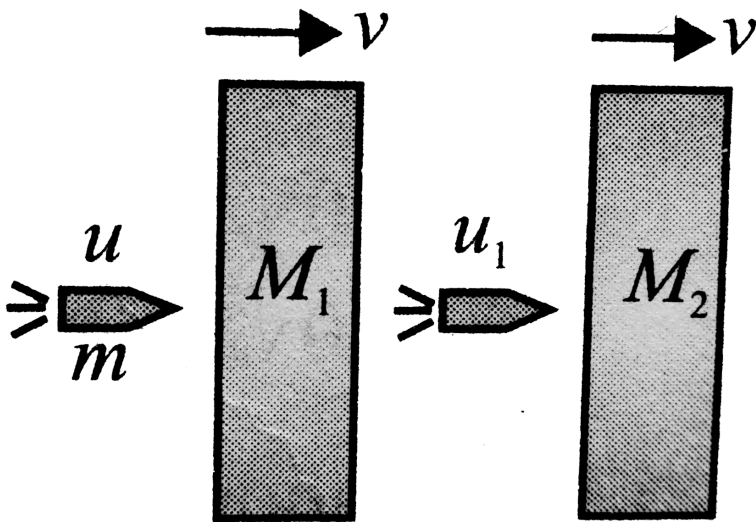
11. A piece of wood of mass 0.03 kg is dropped from the top of a building 100 m high. At the same time, a bullet of mass 0.02 kg is fired vertically upward with a velocity of 100 m/s from the ground the bullet gets embedded in the wooded piece after striking. find the height to which the combination rises above the building before it starts falling take $g = 10m/s^2$

12. A block of mass 0.1 is held against a wall applying a horizontal force of 5N on block. If the coefficient of friction between the block and the wall is 0.5, the magnitude of the frictional force acting on the block is:

13. A body of mass 2 kg is being dragged with uniform velocity of 2 m / s on a rough horizontal plane. The coefficient of friction between the body and the surface is 0.20. The amount of heat

generated in 5 sec is

. $\left(4.2\text{joule}/cal \text{ and } g = 9.8m/s^2\right)$

14. An aeroplane requires for take off a speed of $80km/h$ the run on the ground being 100 m The mass of aeroplane is 10^4 kg and coefficient of friction between aeroplane and ground is 0.2 What is the maximum force required by the engine of the plane for take off ?

15. Aparticle of mass 1 g executes an oscillatory motion on the concave surface of a spherical dish of radius 2m placed on a horizontal plane, Figure . If the motion of the particle begins from a point on the dis at a height of 1 cm. from the horizontal plane and coefficient of friction is 0.01 , fing the total distance covered by the particle

before coming to rest.
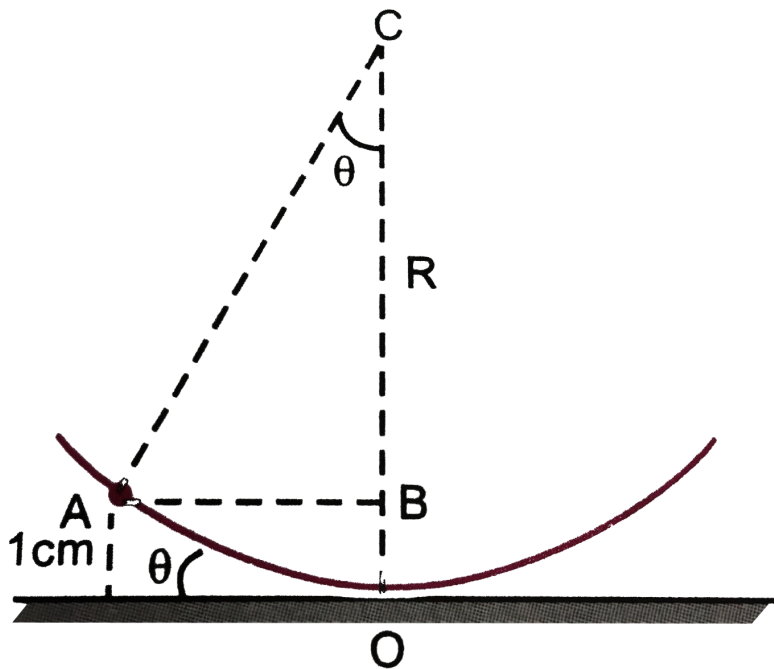
16. A 100 metric ton engine is moving up a slope

of gradient $5°$ at a speed of 100 metre / hour.

The coefficient of friction between the engine and the rails is 0.1. If engine has an efficiency of 4% for converting heat into work, find the amount of coal the engine has to burn in one hour. Burning of 1 kg coal yields 50000J.

17. A particle of mass m rests on a horizontal floor with which it has a coefficient of static friction μ. It is desired to make the body move by applying the minimum possible force F. Find the

magnitude of F and the direction in which it has to be applied.

Self Practice

1. A force acts for 10 s on a body of mass 10 kg after which the force ceases and the body describes 50 m in the next 5 s. Find the magnitude of the force.

2. A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of $400m$ in $20s$. Find its acceleration. Find the force acting on it if its mass is 7 metric tonnes (Hint.1 metric tonne=1000kg)

3. A force of $5N$ gives a mass m_1, an acceleration of $8m/s^2$, and a mass m_2, an acceleration of

$24m/s^2$. What acceleration would it give if both the masses are tied together?

4. A body of mass 1 kg is acted upon by a force of 4000 dyne. As a result, the velocity of the body changes from $30cms^{-1}$ to $20cms^{-1}$ in passing through a certain distance. Find the distance.

5. A motor car of mass 20 quintal moving with velocity of 60 kmh^{-1}, by the application of brakes, is brought to rest in a distance of 3 km. Find the average force of resistance in newton.

6. In an $X - ray$ machine an electron is subjected to a force of $10^{-23}N$ In how much time will the electron a distance of $0.1m$? Take mass of electron $= 10^{-30}kg$.

7. A stone of mass $5kg$ falls from the top of a cliff $50m$ high and buries $1m$ deep in sand . Find the average resistance offered by the sand and the time it takes to penetrate .

8. A bus starts from rest accelerating unifromly with $4ms^{-2}$. At $t = 10s$,a stone is dropped from the window of the bus 2 m high . If

$g = 10m/s^2$, what are the magnitude of velocity and acceleration of the stone at 10 .2 s ?

9. A motor car running at the rate of $7ms^1$ can be stooped by applying brakes in $10m$ Show that total resistance to the motion when brakes are on is one fourth of the weight of the car .

10. A force of $50N$ is inclined to the vertical at an angle of $30°$ Find the acceleration it produes in a body of mass $2kg$ which moves in the horizontal direction .

11. A sooterist moving with a speed of $36kmh^{-1}$ sees a child standing in the middle of the road. He applies the brakes and brings the scooter to rest in 5 s just in time to save child. Calculate the

average retarding force on the vehicle, if mass of the vehicle and driver is 300 kg.

12. A ship of mass $3 \times 10^7 kg$ initially at rest, is pulled by a force of $5 \times 10^5 N$ through a distance of 3m. Assuming that the resistance due to water is negligible, the speed of the ship is

13. A body of mass 5 kg is acted upon by two perpendicular forces of 4 N and 3 N. What is the magnitude and direction of acceleration ?

14. Forces of $5\sqrt{2}$ and $6\sqrt{2}N$ are acting on a body of mass 1000 kg at an angle of $60°$ to each other. Find the acceleration, distance covered and the velocity of the mass after 10 s.

15. A bullet of mass $50g$ moving with a speed of $500ms^{-1}$ is brought to rest in $0.01s$ Find the impulse and the average force .

16. A cricket ball of mass 150 kg is moving with a velocity of $12m/s$ and is hit by a bat so that ball is turned back with a velocity of $20m/s$. The force of the blow acts for 0.01 s on the ball . Find the average force exerted by the bat on the ball.

17. A hammer weighing 3 kg moving with a velocity of $10 ms^{-1}$ strikes against the head fo a spike and drives it into a block of wood. If the hammer comes to rest in 0.025 s, find (i) the impulse and (ii) the average force on the head of the spike.

18. A rubber ball of mass $50g$ falls from a height of $100cm$ and rebounds to a height of $50cm$ Find the impulse and average force between the ball and the ground, if time of contact is $0.1s$.

19. Two billiard balls each of mass 0 .05 kg moving in opposite directions with speed $6ms^{-1}$ collide and rebound with the same

speed What is the impulse imparted to each ball

due to the other ?

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20. A machine gun has a mass of $20kg$ It fires $30g$

bullets at the rate of 400 bullets/s with a sped of

$400m/s$ What force must be applied on the gun

to keep it in position ?

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21. A ball of mass 20 gram hits a wall at an angle of $45°$ with a velocity of $15 m/s$ If ball rebounds at $90°$ to the direction of incidence, calculate the impulse received by the ball.

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22. Two identical billiard balls striks a rigid wall with the same speed but at different angles , and get reflected without any change in speed , as shown in Fig . What is (i) the direction of the
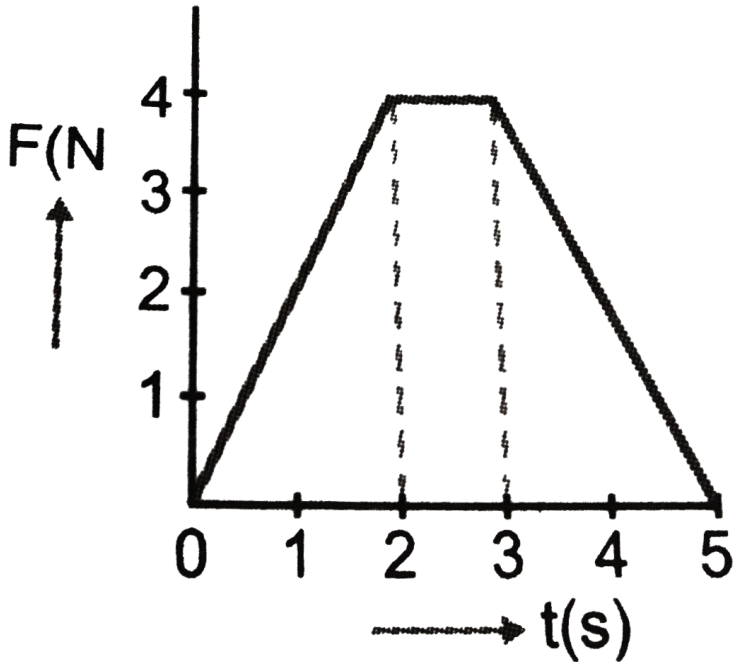
force on the wall due to each ball ? (ii) the ratio of the magnitudes of impulses imparted to the balls by the wall ?

23. A force acting on a body of mass 2 kg varies with time as shown in fig . 20 find impulse of the

force and final velocity of the body.

24. Fig. shows an estimated force-time graph for a base ball struck by a bat. From this curve,

determine

(i) impulse delivered to the ball

(ii) force exerted on the ball

(iii) the maximum force on the ball.

25. An elevator weighing 5000 kg is moving upward and tension in the supporting cable is 5000 N . Find upward acceleration . Starting from rest , how far does it rise in 10 secound ?

26. A body of 100 kg stands on a spring weighing machine inside a lift. The lift starts to ascend with acceleration of $2.2ms^{-2}$. What is the reading of the machine inside a lift. The lift starts to ascend with acceleration of $2.2ms^{-2}$. What is the reading of the machine?

27. A woman weighing 50 kgf stands on a weighing machine placed in lift. What will be the

reading of the machine, when the lift is (i) moving upwards with a uniform velocity of $5ms^{-1}$ and (ii) moving downwards with a uniform acceleration of $1ms^{-2}$? Take g = 10 ms^{-2}.

28. A 75 kg man stands in a lift. What force does the floor does the floor exert on him when the elevator starts moving upwards with an acceleration of $2.0ms^{-2}$.? Take g = $10ms^{-2}$.

29. Find the appared weight of a man weighing 49 kg on earth, when he is standing in a lift which is (i) rising with an acceleration of $1.2m/s^2$ (ii) going down with same acceleration (iii) falling freely under gravity (iv) going up or down with unifrom velocity . Take $g = 9.8m/s^2$.

\

30. A body of mass 15 kg is hung by a spring balance in a lift. What would be the reading of the balance when (i) the lift is ascending with an acceleration of $2ms^{-2}$ (ii) descending with the same acceleration (iii) descending with a constant velocity of $2ms^{-1}$.? Take g = 10 ms^{-2}.

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31. A mass of 10 kg is suspended from a string, the other end of which is held in hand Find the

tension in string when the hand is moved up with a uniform acceleration of $2ms^{-1}$. Given $g = 10ms^{-1}$.

32. The strings of a parachute can bear a maximum tension of $72kg$ wt . By what minimum acceleration can a person of 90 kg descend by means of this parachute ?

33. A 70 kg man in sea is being lifted by a helicopter with the help of a rope , which can bear a maximum tension of 100 kg wt . With what maximum acceleration the helicopter should rise so that the rope does not break ? Take $g = 9.8m/s^2$.

34. An elevator and its load weigh a total of $800kg$ Find the tension T in the supporting cable when the elevator originally moving

downwards at $20m/s$ is brought to rest with constant retardation in a distnce of $50m$.

35. A lift of mass 400 kg is hung by a wire. Calculate the tension in the wire when the lift is (i) at rest (ii) moving upwards with a constant velocity of $1ms^{-1}$ (iii) moving upwards with an acceleration of $2ms^{-2}$ and (iv) moving downwards with an acceleration of $2ms^{-2}$.

36. A 30 g bullet leaves a rifle with a velocity of $300 \ ms^{-1}$ and the rifle recoils with a velocity of $0.60 ms^{-1}$. Find the mass of the rifle.

37. A $40kg$ shell is flying at a speed of $72km/h$ It explodes into two pieces One piece of mass $15kg$ just stops . What is the speed of the other ?

38. A gun weighing 10 kg fires a bullet of 30 g with a velocity of 330 ms^{-1} . With what velocity does the gun recoil? What is the combined momentum of the gun and bullet before firing and after firing?

39. A bullet of mass 4 g is fired with a velocity of 600 ms^{-1} into a block of metal weighing 9.996kg. The block is free to move. Calculate the

common velocity of the bullet and block after the impact.

40. A bullet of mass $7g$ is fired into block weighing $7kg$, which is free to move. Calculate initial velocity of bullet if the velocity of the block with the bullet inside is $0.7m/s$.

41. A truck of mass 2×10^4 kg travelling at $0.5ms^{-1}$ collides with another truck of half its mass moving in the opposite direction with a velocity of $0.4ms^{-1}$. If the trucks couple automatically on collision, calculate the common velocity with which they move.

42. A neutron of mass 1.67×10^{27} kg moving with a speed of $3 \times 10^6 ms^{-1}$ collides with a

deutron of mass 3.34×10^{-27} kg which is at rest. After collision, the neutron sticks to the deutron and forms a triton. What is the speed of the triton?

43. A bomb at rest explodes into three fragments of equal massses Two fragments fly off at right angles to each other with velocities of $9m/s$ and $12/s$ Calculate the speed of the third fragment .

44. A man weighing $60kg$ runs along the rails with a velocity of $18km/h$ and jumps into a car of mass 10 quintal standing on the rails. Calculate the velocity with which the car will start travelling on the rails .

45. A machine gun of mass 10 kg fires 20 g bullets at the rate of 10 bullets per second with a

speed of 500 ms^{-1}. What force is required to hold the gun in position ?

46. A rocket with a lift mass of 10,000 kg is blasted upwards with an acceleration of $10ms^{-2}$. Calculate the initial thrust of the blast

47. Fuel is consumend at the rate of 50 g per second in a rocket. The exhaust gases are rejected at the rate of $5 \times 10^5 cms^{-1}$. What is the thrust experienced by the rocket?

48. Calculate the ratio m_0/m for a rocket to attain the escape velocity of $11.2 kms^{-1}$ after starting from rest, when maximum exhaust velocity of gases is $1.6 km/s$.

49. In the first second of its flight a rocket ejects $\frac{1}{60}$ of its mass with a reative velocity $2073 ms^{-1}$ What is the initial acceleration of the rocket ? .

50. A rocket motor consumes 100 kg of fuel per second exhausting it with a speed of $6 \times 10^3 ms^{-1}$ What thrust is exerted on the rocket ? What will be the velocity of the rocket at

the instant its mass is reduced to $(1/40)$ of its initial mass ? Take initial velocity of rocket as zero . Neglect gravity .

51. A rocket fired from the earth's surface ejects 1% of its mass at a speed of $2000\ ms^{-1}$ in the first second. Find the average acceleration of the rocket in the first second.

52. If an ion engine with an exhaust velocity of $10^8 ms^{-1}$ could be constructed, what percentage of the initial mass would have to be fuel if the engine were to be used to power a rocket that could attain the escape velocity of $11.2 kms^{-1}$? Neglect gravity and air resistance.

53. A ballon of mass m is rising up with an acceleration a show that the fraction og weight of balloon that must be detached in order to

double its acceleration , assuming the upthrust of air to remain the same
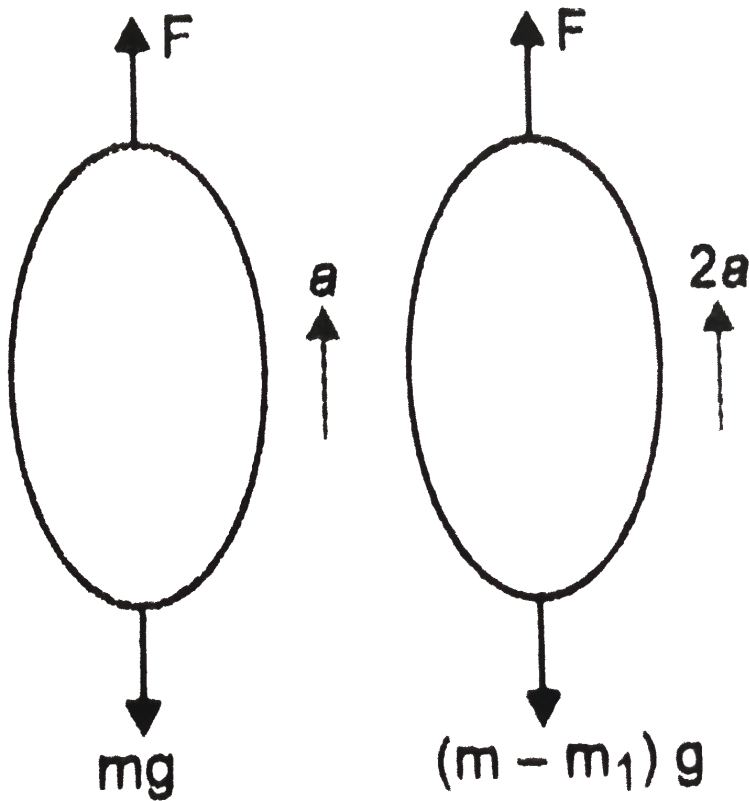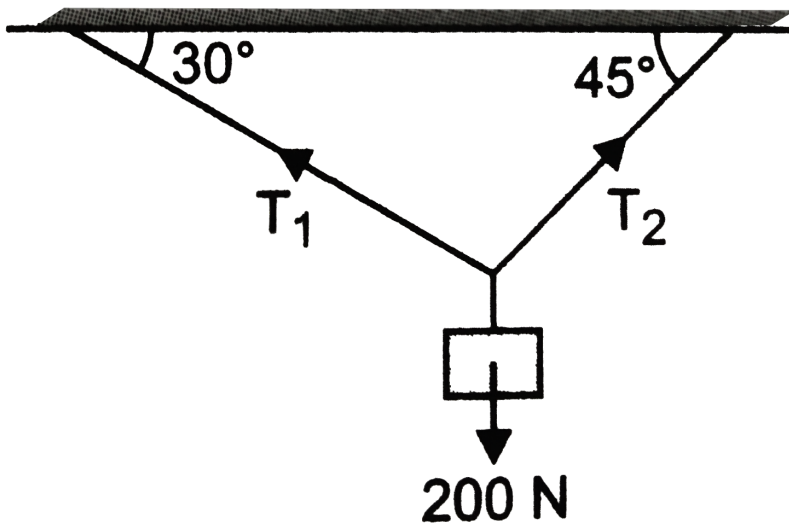
54. A mass of 10 kg is suspended vertically by a rope of length 2 m from a ceiling. A force of 60 N is applied at the middle point of the rope in the horizontal direction, as shown in Fig. Calculate the angle the rope makes with the vertical. Neglect the mass of the rope and take $g = 10ms^{-2}$.
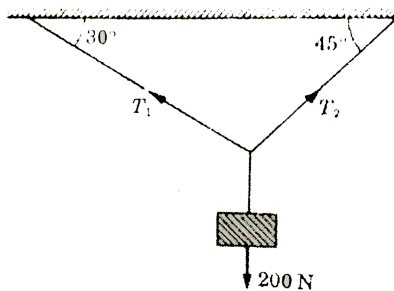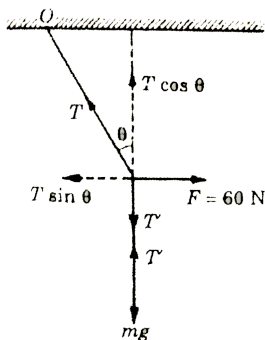
55. A body of weight $200N$ is suspended with the help of strings as show in Find the tensions in the strings

$30°$ $\qquad$ $45°$

T_1 $\qquad$ T_2

200 N

.

56. A car moving on a level rosd. A pendulum suspended from the ceiling makes an angle of $10°$ with the vertical. Find the acceleration of the car. Take $g = 10ms^{-2}$.

57. A mass of 20 kg is suspended by a rope of length 2 m from a ceiling. A force of 173.2 N in the horizontal direction is applied at the midpoint of the rope as shown in Fig. What is

the angle the rope makes with the horizontal in equilibrium ? Take $g = 10ms^{-2}$. Neglect mass of the rope.
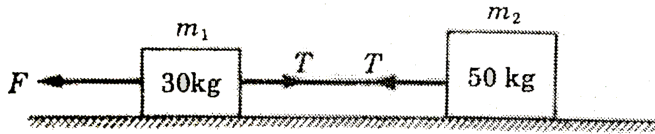

$200\sqrt{3}$ N

θ

1 m

1 m

20 kg
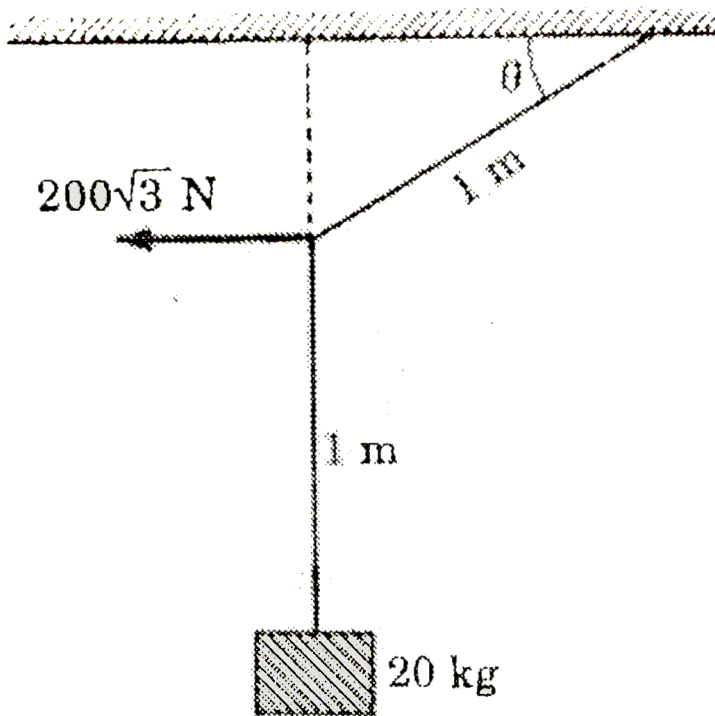
58. A force of 9 N pulls a block of 4 kg through a rope of mass 0.5 kg. The block is resting on a smooth surface. What is the force of reaction exerted by the block on the rope?

59. Two masses m_1 and m_2 are connected by a massless string as shown in Fig. Find the value of tension in the string if a force of 200 N is applied

on (i) m_1 and m_2.

60. Two bodies whose masses are $m_1 = 50kg$ and $m_2 = 150kg$ are tied by a light string and are placed on a frictionless horizontal surface When m_1 is pulled by force F an acceleration of $5ms^{-2}$ is produced in both the bodies Calculate the value of F What is the tension in the string 1 ?

61. As shown in Fig. three masses m, 3m and 5m connected together lie on a frictionless horizontal surface and pulled to the left by a force F. The tension T_1 in the first string is 24 N. Find (i) acceleration of the system, (ii) tension in the second string, and (iii) force F.
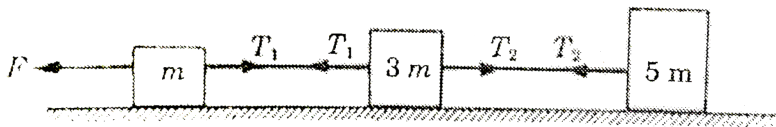
62. Three identical blocks, each having a mass M, are pushed by a force F on a frictionless table as shown in (figure) What is the acceleration of the blocks? What is net force on block A? What force does A apply on B? What force does B apply on C? show action reaction pairs on the contact surface of the blocks.

63. Four blocks of the same mass m connected by cords are pulled by a force F on a smooth

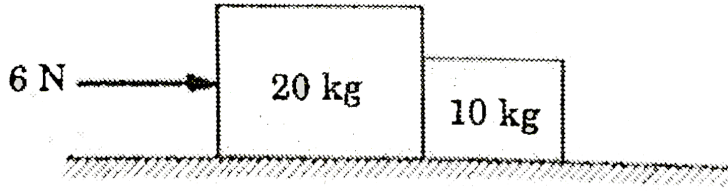horizontal surface as shown in Determine the tensions T_1, T_2 and T_3 in the cords.

64. A shown in Fig. two blocks are placed in contact on a smooth table. A horizontal force of 6 N is applied on 20 kg block. (i) With what force does the block press the 10 kg block ? (ii) If the same force is applied on 10 kg block, with what
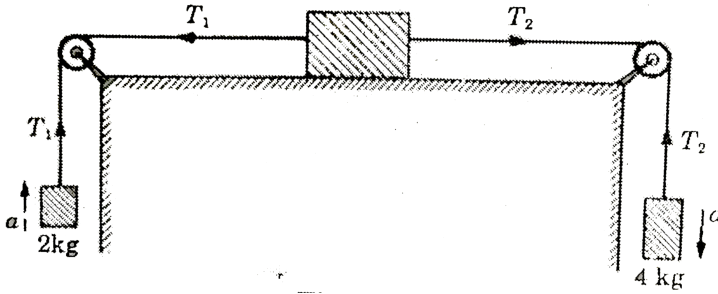
force will the 20 kg block press the 10 kg block ?

65. In Fig. find the acceleration a of the system and the tesnions T_1 and T_2 in the strings. Assume that the table and the pulleys are frictionless and the strings are massless. Take g =
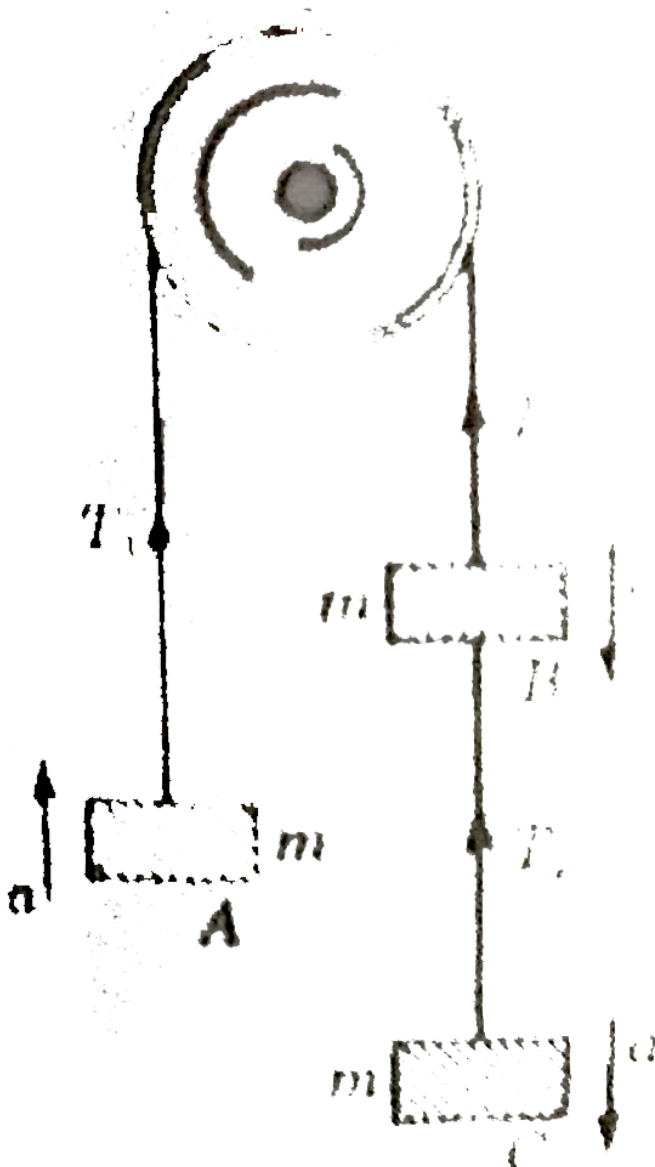
$9.8ms^2$

66. Two bodies of masses $4kg$ and $3kg$ respectively are connected by a light string passing over a smooth frictionless pulley Calculate the acceleration of the masses and tension in the string .

67. In the Atwood's machine the system starts

from rest. What is the speed and distance moved

by each mass at t = 3s?

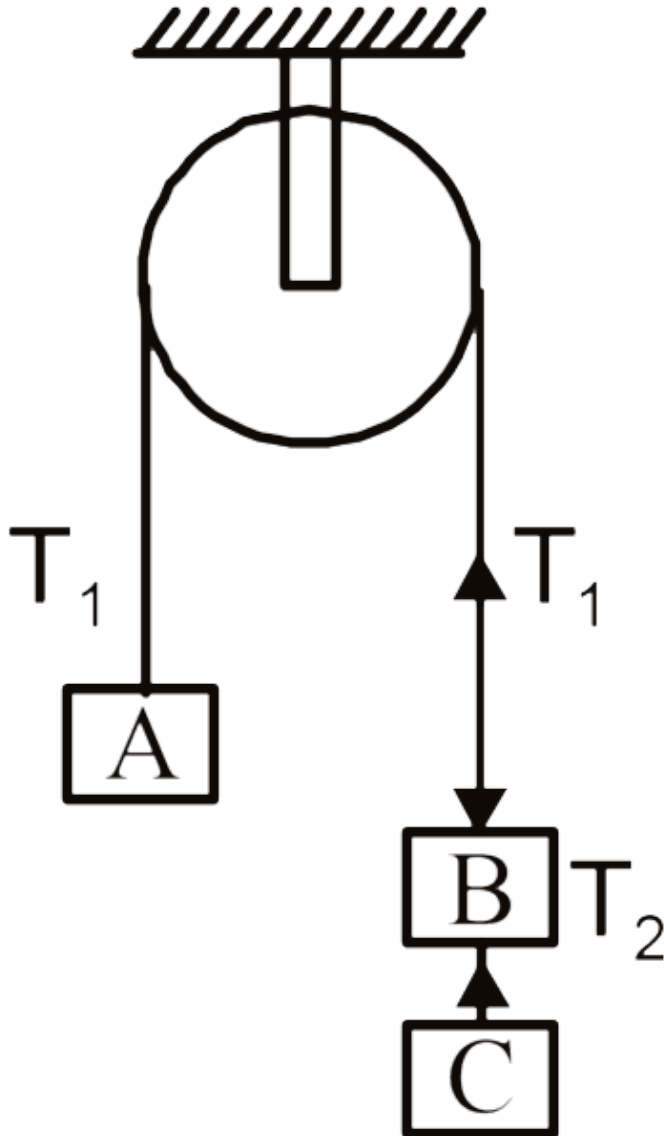**68.** Three equal weights of mass m each are hanging on a string passing over a fixed pulley as shown in fig. The tensions in the string connecting weights A to B and B to C will

respectively   be   -

T_1

A

T_1

B T_2

C

69. In the arrangement shown in show that tension in the string between masses m_2 and m_3 is $T = \dfrac{2m_1 m_3 g}{m_1 + m_2 + m_3}$

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70. A block of mass 1 kg lies on a horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6. If the acceleration of the truck is $5m/s^2$, the

frictional force acting on the block is............ newtons.

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71. A horizontal force of 490 N is required to slide a sledge weighing 600 kg f over a flat surface. Calculate the coefficient of friction.

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72. A body weighing 20 kg just slides down a rough inclined plane that rises 5 m in every 13 m. What is the coefficient of friction?

73. A body is rolling on the ground with a velocity of $1ms^{-1}$. After travelling a distance of 5 m, it comes to rest. Find the coefficient of friction. Take $g = 10ms^{-2}$.

74. A scooter weighs 120 kg f. Brakes are applied so that wheels stop rolling and start skidding. Find the force of friction if the coefficient of friction is 0.4.

75. An automobile is moving on a horizontal road with a speed v If the coefficient of friction between the tyres and the road is μ show that

the shortest distance in which the automobile can be stooped is $v^2/2\mu g$.

76. Find the distance travelled by a body before coming rest, if it is moving with a speed of $10ms^{-1}$ and the coefficient of friction between the ground and the body is 0.4.

77. A motor car running at the rate of $7ms^1$ can be stooped by applying brakes in $10m$ Show that total resistance to the motion when brakes are on is one fourth of the weight of the car .

78. Find the power of an engine which can maintain speed of $50ms^{-1}$ for a train of mass 3×10^5 kg on a rough line. The coefficient of friction is 0.05. Take $g = 10ms^{-2}$

79. A train weighing 1000 quintals is running on a level road with a unifrom speed of $72km/h$ If the frictional resistance amounts to 50g wt. per quintal find power in watt, take $g = 9.8ms^2$.

80. An automobile of mass m starts from rest and accelerates at a maximum rate possible without slipping on a road with $\mu_s = 0.5$. If only

the rear wheels are driven and half the weight of the automobile is supported on these wheels, how much time is required to reach a speed of $100\ kmh^{-1}$.

81. A suitcase is gently dropped on a conveyor belt moving at $3ms^{-1}$ If the coefficient of friction between the belt and suitcase is 0.5 how far will the suitcase move on the belt before coming to rest ?

82. A truck moving at $72 kmh^{-1}$ carries a steel girder which rests on its wooden floor. What is the minimum time in which the truck can come to stop without the girder moving forward ? Coefficient of static friction between steel and wood is 0.5.

83. A bullet of mass 10 gram is fired horizontally into a 5 kg wooden block at rest on a horizontal surface The coefficient of kinetic friction between the block and the surface is 0.1 Calculate the speed of the bullet striking the block if the combination moves 20 m before coming rest .

84. In the masses of A and B are 10 kg and 5 kg . Calculate the minimum mass of C which may

stop A from slipping Coefficient of static friction

between block A and table is 0.2
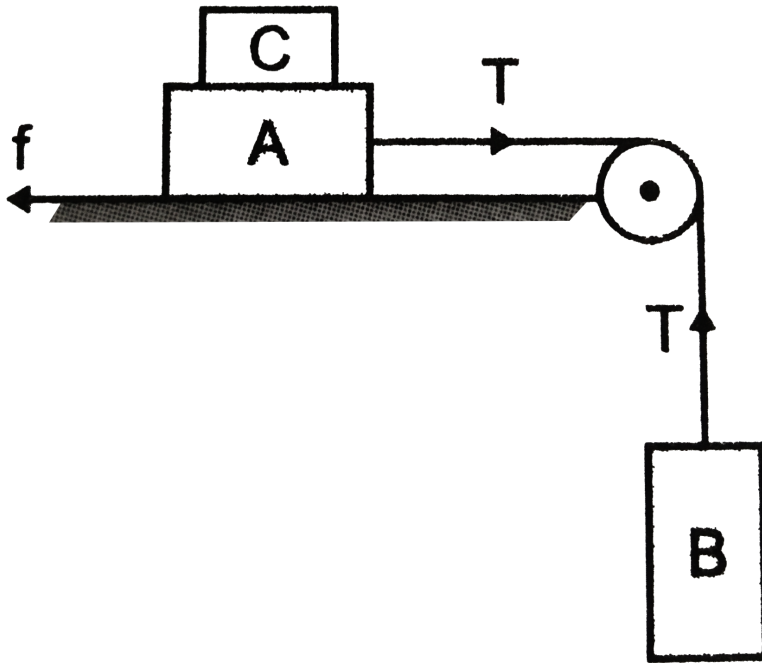
85. A block of mass 2kg rests on a rough inclined plane making an angle of $30°$ with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is

86. A block of mass 10 kg is sliding on a surface inclined at $30°$ with horizontal . If coefficient of friction between the block and the surface is 0.5 ,

find acceleration produced in the block . Take $g = 9.8m/^2$.

87. Find the force required to move a train of mass 10^5 kg up an incline of 1 in 50 with an acceleration of $2ms^{-2}$. Coefficient of friction between the train and rails is 0.005 . Take $g = 10^2$.

88. A block slides down an incline of angle $30°$ with an acceleration of $g/4$ Find the coefficient of kinetic friction .

89. A body just slides a rough plane inclined at an angle of $30°$ with the horizontal. Calculate the acceleration with which the body will slide down when the inclination in the plane is changed to $45°$. Take $g = 9.8ms^{-2}$

90. A 10 kg block slides without acceleration down a rough inclined plane making an angle of $20°$ with the horizontal. Calculate the acceleration when the inclination of the plane is increased to $30°$ and the work done over a distance of $1.2m$. Take $g = 9.8ms^{-2}$.

91. Calculate the power of an engine which can pull a train of mass 25000 quintal up an incline of 1 in 100 at the rate of $10.8km/h$ Resistance due to friction is $2N/\text{quintal}$.

92. A railway engine weighing 40 metic ton is travelling along a level track at a speed of $54kmH^{-1}$ What additional power is required to

maintain the same speed up an incline of 1 in 49

Take $g = 9.8m/s^2$ and $u = 0.1$.

93. A metal block of mass 0.5 kg is placed on a plane inclined to the horizontal at an angle of $30°$. If the coefficient of friction is 0.2, what force must be applied (i) to just prevent the block from sliding down the inclined plane (ii) to just move the block up the inclined plane and (iii) to

move it up the inclined plane with an acceleration of $20 cms^{-2}$?

94. A block A of mass 14 kg moves alongg an inclined plance that makes an angle of $30°$ with the horizontal . This block is connected to another block B of mass 14 kg by a taut massless string that runs around a massless frictionless pulley . The block B moves down with constant

velocity . Calculate force of friction and coefficient of kinetic friction .

95. A wooden block of mass 100 kg rests on a flat wooden floor, the coefficient of friction between the two being 0.4. The block by a rope making an angle of $30°$ with the horizontal. What is the minimum tension along the rope that just makes the rope sliding?