PHYSICS

BOOKS - S CHAND PHYSICS (ENGLISH)

FRICTION

Work Out Examples

1. An ice skater moving at $10m/s$ comes to a halt in $100m$ on a ice surface. Calculate the

coefficient of friction between the ice and the skater ?

2. A body moving with a speed of 54kmph is brought to rest in a distances. If the coefficient of friction between the body and the surface is 0.3. Calculate the distance travelled by the body ?

3. A block of mass 10kg is dragged across a horizontal surface by pulling the block with force of 100N. The force is applied by attaching a chord to the block. The chord is inclined at an angle of $60°$ with the horizontal. If the coefficient of kinetic friction is 0.2 what is the acceleration of the block ?

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4. A body of mass 25 kg is at rest on a horizontal surface. Minimum horizontal force

required to just start motion is $73.5N$ and a force of 49N is needed to keep the body moving with a constant velocity. What is the coefficient of (i) static friction and (ii) kinetic friction ?

5. A body of mass 10 kg is placed on a horizontal wooden plank of length $0.75m$. One end of the plank is slowly raised by keeping the other end at rest on the ground, as shown

in . When the other end is at a height of 0.30m, the body begins to just slide down the plank. What is the coefficient of friction between the body and the plank ?

6. A car is travelling on an inclined road of inclination $30°$, with a speed of 27 kmph. If the engine of the car is switched off how far up in the plane will car move before coming to rest,

if the coefficient of friction between the tyre and the road is 0.4.

7. The time taken for an ice block to slide down on inclined surface of inclination $60°$ is 1-2 times the time taken by the same ice block to slide down a frictionless inclined plane of the same inclination. Calculate the coefficient of friction between ice and the inclined plane ?

8. If the inclination of an inclined plane is $30°$, a block of mass m kept at rest on the surface of the plane, will just slide down. If the inclination is raised to $45°$ what will be the acceleration of the body ?

9. A bullet of mass 5gm is fired horizontally into block of mass 1kg at rest on a horizontal

surface and gets embedded in it. The combination moves 5m before coming to rest. If $\mu_k = 0.40$, what is the speed with which the bullet strikes the block ?

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Additional Solved Examples

1. The length of a uniform ladder of mass m is 1. It leans against a smooth wall making an angle θ with the horizontal. What should be

the force of friction between the floor and ladder so that the ladder does not slip ?

2. A heavy uniform metal chain is kept on the surface of a horizontal table. The coefficient of friction between the chain and the table surface is 0.22. Find the maximum fraction of length of the chain that could hung over on one edge of the table ?

3. A block of mass 5kg is put on the top of a 6kg block placed on a frictionless table. A horizontal force of 15N must be applied to stop the top block to cause it to slip on the bottom block as shown in Fig.. Find the maximum horizontal force F that must be applied to the lower block so that the blocks will move together and the resulting acceleration of the blocks.

4. A block of mass $0.5kg$ is kept pressed against a vertical wall by applying a force F of 12N as shown in fig. The coefficient of static friction between the wall an the block is 0.6 and the coefficient kinetic friction is 0.4. Assuming the block is not moving initially . (a) Will the block start moving ? (b) Find the force exerted on the block by the wall.

5. In fig. A is a 1kg block and B is a $0.5kg$ block. (a) Find the minimum weight of block C which must be placed on A to keep it from sliding , if μ_s between A and the table is 0.2. The block C is suddenly lifted off A. What is the acceleration of block A if μ_k between A and the table is 0.2 ?

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6. In fig m_1 and m_2 are two blocks of masses $m_1 = 1.5kg$ and $m_2 = 3kg$ attached by a massless rod parallel to the incline on which both slide, travel down along the plane with m_1 trailing m_2. The angle of the inclined plane is $\theta = 45°$. The coefficient of kinetic friction between m_1 and the incline is $\mu = 0.3$ and that between m_2 and the incline is $\mu_2 = 0.15$. Find (a) the tension in the rod linking m_1 and m_2 and (b) the common acceleration of the two masses.

7. The rear side of a truck is open and a box of 40kg mass is placed $5m$ away from the open end as shown. 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 $2ms^{-2}$. At what distance from the starting point does the box fal off the truck ? (Ignore the size of box)

8. A body of mass 0.3kg is taken up an inclined plane of length 10m and height 5m, and then allowed to slide down to the bottom again. The coefficient of friction between the body and the plane is 0.15. What is the

(a) work done by the gravitational force over the round trip.

(b) work done by the applied force over the upward journey

(c) work done by frictional force over the round trip.

(d) kinetic energy of the body at the end of the trip.

How is the answer (d) related to the first three answers ?

$$m = 0.3kg, OA = 10m, BA = 5m$$

9. Masses M_1 , M_2 and M_3 are connected by strings of negligible mass which pass over massless and frictionless pulleys P_1 and P_2 as shown in the fig. The masses move such that

the portion of the string between P_1 and P_2 is parallel to the incline and the portion of the string between P_2 and M_3 is horizontal. The masses M_3 and M_2 are $4.0kg$ each and the coefficient of kinetic friction between the masses and the surface is 0.25. The inclined plane makes an angle of $37°$ with the horizontal. Find the mass M_1.

1. "We slip on a muddy road". Why ?

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2. Is it unreasonable to expect a coefficient of friction to exceed unity ?

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3. There is a limit beyond which further polishing of a surface increases rather than decreases frictional force. Explain.

4. "When a person walks on a rough surface the frictional force exerted by the surface on the person is opposite to the direction of his motion". Is it true or false ?

5. "It is easier to make a body roll over a surface than to slide". Why ?

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6. "It is difficult to run fast on sand ". Why?

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7. "It is difficult to move a cycle along the road with its brakes on". Why?

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8. Is a large brake on a bicycle more effective than a small one ?

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9. "A horse has to apply more force to start a cart than to keep it moving ". Why?

Long Answer Questions

1. Explain the various forces in nature. What are their charateristics. Give their relative strengths.

2. (a) What is friction ? Give its advantages and disadvantages.

(b) Mention a few methods of reducing friction

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Short Answer Question

1. What are contact forces ? Give examples.

2. Give the relative strengths of the four forces

in nature.

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3. What is super force ?

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4. What is GUT ?

5. Explain the origin of friction.

6. "The friction between two surfaces increases when the surfaces are made smoother and smoother " . Why ?

7. What is static friction ? Why is it called so ?

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8. What is limiting friction?

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9. Explain dynamic friction ?

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10. State the laws of static friction.

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11. Explain the laws of kinetic friction.

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12. Define the coefficient of static friction and kinetic friction.

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13. What is angle of friction?

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14. Define angle of repose. Is this angle equal to the angle of friction ?

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15. In the case of a body sliding down a rough inclined plane show that $\mu_s = \tan\theta$

16. What is rolling friction ? How does it arise ?

17. What is the relation connecting rolling friction and the radius of the roller ?

18. "Friction is a necessary evil". Why ?

19. Name four different methods of reducing friction.

20. What are antifriction metals ?

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21. Name a few methods of increasing friction.

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22. "A horse has to pull a cart harder during the first few metres of its motion than later on ". Why ?

23. "Rosin is rubbed on the violin bow ". Why ?

24. Derive an expression for the acceleration of

a body sliding down a rough inclined plane.

25. Explain why a high pressure tyre roll more easily than a low pressure tyre ?

26. The surfaces of the train wheels and railway tracks are made smooth ". Why ?

27. A body moving on a surface is brought to rest suddenly. What happens to the friction between the two ?

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28. "In hilly areas, sand is thrown on tracks covered with snow ". Why ?

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29. "Proper inflation of tyres can save fuel".

Explain how ?

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30. Explain why the shapes of high-speed

vehicles are streamlined ?

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Very Short Answer Question

1. What is (i) dry friction and (ii) fluid friction ?

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2. It is easier to roll than to pull a barrel along

a road. Explain.

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3. "Friction is a self adjusting force" Why ?-

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4. Explain how lubricants help in reducing friction ?

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5. "The dynamic friction is a little less than the limiting friction ". Why ?

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6. "A parachute descends slowly " Why ?

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7. Name one factor on which the coefficient of friction depends.

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8. "Carts with rubber tyres are better than those with iron tyres". Why ?

9. Is friction , a conservative or non-conservative force ?

Selected Problems

1. A force of 3kg wt is sufficient to pull a block of 4kgwt over a flat surface. What is the angle

of friction ?

2. A block of 10kg is pulled at a constant speed on a rough horizontal plane by a force of $20N$. Calculate the coefficient of friction ?

3. A body weighing 20kg just slides down a rough inclined plane that rises 5 in 12. What is

the coefficient of friction ?

4. A motor car running at the rate of $7m/s$ can be stopped by brakes in $10m$. Prove that the total resistance to the motion when the brakes are on is one-fourth of the weight of the car.

5. A mass of 200kg is resting on a rough inclined plane of angle $30°$. If the coefficient of friction is $1/\sqrt{3}$, find the greatest and the least force acting parallel to the plane which can just maintain the mass in equilibrium.

6. A block of mass 50kg is placed as a horizontal table. A spring balance is attached to it and is pulled by gradually increasing the

force. When the body just moves, the reading of the spring balance is $50N$. Find the coefficient of friction.

7. A block of mass 50kg rests on a rough horizontal plane whose coefficient of static friction is 0.3. What is the least force required to just move it if it is pulled (i) horizontally and (ii) at $45°$ to the horizontal.

8. Find the force required to pull a block of mass 100kg up an incline of $8°$ at a uniform speed of $5m/s$. The coefficient of friction between the block and the plane is 0.3.

9. A piece of ice slides down a $45°$ incline in twice the time it takes to slide down a frictionless $45°$ incline . What is the coefficient of friction between the ice and the incline ? .

10. A block slides on ice with a velocity of $5m/s$ comes to rest after moving through a distance of $13.5m$. Find the coefficient of friction ?

11. A block placed on an inclined plane making an angle $17°$ with the horizontal slides down

without any acceleration. What is the acceleration of the block if the inclimation is increased to $30°$?

12. A block of mass 5kg is placed on a rough horizontal plane whose coefficient of friction is 0.3. Find the least horizontal force needed to move the block along the plane and the resultant of normal reaction and the force applied.

13. A block kept on a inclined plane slides down the plane with constant velocity when the slope angle of the plane is θ. It is then projected up with an initial velocity u. How far up the incline will it move before coming to rest ? Will it slide down again ?

14. If the coefficient of friction between the tyres of a car and the road is μ_k, show that the maximum stopping distance of the car when moving with a velocity v is $v^2 / 2\mu_k g$

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15. A block is placed at the top of an inclined plane 5 m long. The plane makes an angle of $60°$ with the horizontal. If the coefficient of friction between the wood and the plane is 0.3

, find the time taken by the block of slide down the bottom of the plane.

16. A block of mass 15 kg is placed on a long trolley . The coefficient of friction between the block and the trolley is 0.18. The trolley accelerates from rest with $0.5ms^{-2}$ for 20s and then moves with uniform velocity. Discuss the motion of the block as viewed by (a) a

stationary observer on the ground (b) as observer moving with the trolley.

17. A body of mass 20 kg is resting on a table. A light string is attached to it and passed over a smooth pulley at the edge of the table and a mass 3kg is attached at the free end. What is the acceleration of the system of the coefficient of kinetic friction between the mass

and the table is 0.04 ? What is the tension in the string ?

18. A mass of 2kg rests on a horizontal plane. The plane is gradually inclined until at an angle $\theta = 20°$ with the horizontal, the mass just begins to slides. What is the coefficient of static friction between the block and the surface ?

19. A body of mass 2kg collides with a horizontal weight spring of force constant $4Nm^{-1}$. The body compresses the spring by 1m from rest position. Find the speed of the block at the instant of collision ? Given that the coefficient of kinetic friction between the body and the surface is 0.1.

20. A train of mass 400 tons climbs up an incline of $1/49$ at the rate of $36 kmh^{-1}$. The force of friction is 4kg' at per ton. Find the power of the engine.

21. A roller of mass 500kg is attached by a light horizontal chain to a tractor of mass 500kg. Assume the force of friction exerted by the ground to be 1000N. If the system has a

forward acceleration of $2ms^{-2}$, calculate (i) the total force required for the motion and (ii) the tension in the chain.

22. A block of mass 10kg slides down an inclined plane of inclination $30°$ with an acceleration of $g/3$. What is the coefficient of kinetic friction between the block and the plane ?

23. Two blocks of masses 22 kg and 18kg are connected by a massless rope. They are dragged by a horizontal force of 100N. The coefficient of friction between each block and the surface is 0.20. What is the magnitude of the acceleration of the system ?

24. A body of mass m is kept on an inclined plane . The force required to just move a body up the inclined plane is double the force required to just prevent the body from sliding down the plane. If the coefficient of friction is μ, what is the inclination of the plane ?

25. A block of mass m is attached to a cart of mass M as shown in . The coefficient of friction

between the block and the cart is μ. What is the minimum accerlertion of the cart so that the block does not fall ?

26. A 40kg slab rest on a frictionless floor as shown in . A 10kg blocks rests on the top of the slab. The static coefficient of friction between the block and the slab is 0.60, while kinetic friction is 0.40. The 10kg block is acted

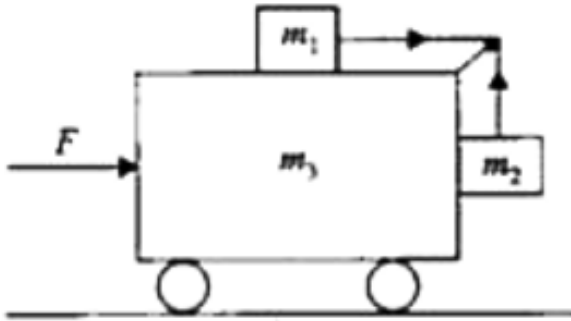upon by a horizontal force of 100N. What is the resulting acceleration of the slab ?

27. In $m_1 = 1kg$, $m_2 = 2kg$ and $m_3 = 10kg$. Find the horizontal force F that must be continuously applied on the system to m_3 so that m_1 and m_2 do not move relative to m_3.

(Assume that the whole system is friction less).

28. A uniform ladder which is 5m long has a

mass of 25kg , leans with its upper end against

a smooth vertical wall and its lower end on

rough ground. The bottom of the ladder is $3m$

from the wall. Calculate the frictional force

between the ladder and the ground .
$(g = 10ms^{-2})$

29. A horizontal force of 1N is needed to keep a block of mass $0.25kg$ sliding on a horizontal surface with a constant speed. Find the coefficient of sliding friction. $(g = 10ms^{-2})$

30. A horizontal turn table rotates about its axis at the uniform rate of 2revolutions per second. Find the maximum distance from the axis at which a small body will remain stationary on the turn table if the coefficient of static friction between the turn table and body is 0.8. Assume $g = \pi^2 m/s^2$.

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