Exercise-1

Marked Questions can be used as Revision Questions.

OBJECTIVE QUESTIONS

Section (A) : Kinetic Friction

A-1. A block is placed at an inclined plane making angle of 60° with horizontal. The coefficient of friction between block and plane is 0.25. If g = 10 m/s^2 then the acceleration of block will be-
(1) 8.66 m/s^2 (2) 5 m/s^2 (3) 7.41 m/s^2 (4) 2.5 m/s^2

A-2. A particle is projected along a rough plane inclined above the inclined at an angle of 45° with the horizontal, if the coefficient of friction is $\frac{1}{2}$, then the retardation is-
(1) $\frac{g}{\sqrt{2}}$ (2) $\frac{g}{2}$ (3) $\frac{g}{\sqrt{2}}\left(1+\frac{1}{2}\right)$ (4) $\frac{g}{\sqrt{2}}\left(1-\frac{1}{2}\right)$

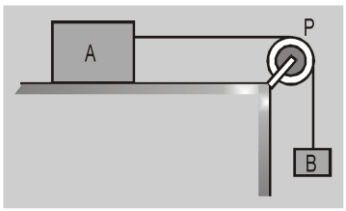
A-3. An inclined plane is inclined at an angle θ with the horizontal. A body of mass m rests on it, if the coefficient of friction is μ, then the minimum force parallel to the inclined plane that has to be applied to the body just move up the inclined plane is-
(1) mgsinθ (2) μmgcosθ
(3) μmgcosθ – mgsinθ (4) μmgcosθ + mgsinθ

A-4 A brick of mass 2kg just begins to slide down an inclined plane at an angle of 45º with the horizontal. The force of friction will be -
(1) 19.6 (2) 19.6 sin 45º (3) 9.8 sin 45º (4) 9.8 cos 45º

A-5. A body is projected along a rough horizontal surface with a velocity 6 m/s. If the body comes to rest after travelling a distance 9m, the coefficient of sliding friction is (g = 10 m/s^2)
(1) 0.5 (2) 0.6 (3) 0.4 (4) 0.2

Section (B) : Static Friction

B-1. The blocks A and B are arranged as shown in the figure. The pulley is frictionless. The mass of A is 10 kg. The coefficient of friction between block A and horizontal surface is 0.20. The minimum mass of B to start the motion will be-
(1) 2 kg (2) 0.2 kg
(3) 5 kg (4) 10 kg



B-2. If the coefficient of friction of a surface is $\sqrt{3}$, then the angle of inclination of the plane to make a body on it just to slide, is-
(1) 30° (2) 45° (3) 60° (4) 750°

B-3. The frictional force is-
(1) Self adjustable (2) Not self adjustable
(3) scalar quantity (4) Equal to the limiting force

B-4. A box is lying on an inclined plane. If the box starts sliding when the angle of inclination is 60°, then the coefficient of static friction of the box and plane is-

(1) 2.732 (2) 1.732 (3) 0.267 (4) 0.176

B-5. A 20 kg block is initially at rest. A 75 N force is required to set the block in motion. After the motion, a force of 60 N is applied to keep the block moving with constant speed. The coefficient of static friction is-

(1) 0.6 (2) 0.52 (3) 0.44 (4) 0.375

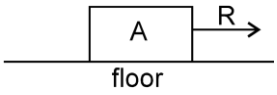
B-6. A block of metal is lying on the floor of a bus. The maximum acceleration which can be given to the bus so that the block may remain at rest, will be-

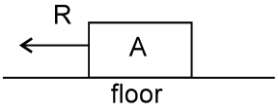
(1) μg (2) $\frac{\mu}{g}$ (3) $\mu^2 g$ (4) μg^2

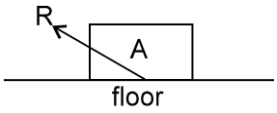
B-7. If the normal force is doubled, the co-efficient of friction is :

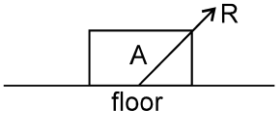
(1) halved (2) doubled (3) tripled (4) not changed

B-8. A box 'A' is lying on the horizontal floor of the compartment of a train running along horizontal rails from left to right. At time 't', it retards. Then the reaction R by the floor on the box is given best by :

(1) 

(2) 

(3) 

(4) 

B-9. A rope so lies on a table that part of it lays over. The rope begins to slide when the length of hanging part is 25 % of entire length. The co-efficient of friction between rope and table is:

(1) 0.33 (2) 0.25 (3) 0.5 (4) 0.2

B-10. 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 5 m/s^2, the frictional force acting on the block is :

(1) 5 N (2) 6 N (3) 10 N (4) 15 N

B-11. A block of mass 2 kg rests on a rough inclined plane making an angle of 30^0 with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is :

(1) 9.8 N (2) $0.7 \times 9.8\sqrt{3}$ N (3) 9.8×7 N (4) 0.8×9.8 N

B-12. The coefficient of static friction between two surfaces depends on -

(1) Nature of surfaces (2) The shape of the surfaces in contact
(3) The area of contact (4) All of the above

B-13. A block of mass 2kg is placed on the floor. The coefficient of static friction is 0.4. Force of 2.8N is applied on the block. The force of friction between the block and the floor is -

(1) 2.8 N (2) 8 N (3) 2.0 N (4) zero

Section (C) : Miscellaneous Questions

C-1. A block of mass 5 kg and surface area 2 m^2 just begins to slide down on an inclined plane when the angle of inclination is 30º. Keeping mass same, the surface area of the block is doubled. The angle at which this starts sliding down is :
(1) 30º (2) 60º (3) 15º (4) none

C-2. A 60 kg body is pushed horizontally with just enough force to start it moving across a floor and the same force continues to act afterwards. The coefficient of static friction and sliding friction are 0.5 and 0.4 respectively. The acceleration of the body is :
(1) 1 m/s^2 (2) 4.9 m/s^2 (3) 3.92 m/s^2 (4) 6 m/s^2

C-3. A body of mass 10 kg lies on a rough horizontal surface. When a horizontal force of F newtons acts on it, it gets an acceleration of 5 m/s^2. And when the horizontal force is doubled, it gets an acceleration of 18 m/s^2. The coefficient of friction between he body and the horizontal surface is -
(1) 0.2 (2) 0.4 (3) 0.6 (4) 0.8

Exercise-2

Marked Questions can be used as Revision Questions.

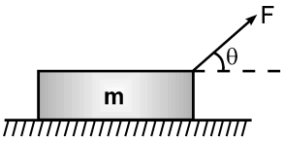
PART - I : OBJECTIVE QUESTIONS

1. A body is projected up a rough inclined plane from the bottom with some velocity . It travels up the incline and then returns back. If the time of ascent is t_a and time of descent is t_d, then
(1) $t_a = t_d$ (2) $t_a > t_d$ (3) $t_a < t_d$ (4) data insufficient

2. A block A kept on an inclined surface just begins to slide if the inclination is 30°. The block is replaced by another block B and it is found that it just begins to slide if the inclination is 40° -
(1) mass of A > mass of B (2) mass of A < mass of B
(3) mass of A = mass of B (4) all the three are possible

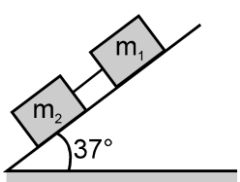
3. It is easier to pull a body than to push, because-
(1) the coefficient of friction is more in pushing than that in pulling
(2) the friction force is more in pushing than that in pulling
(3) the body does not move forward when pushed.
(4) none of these

4. A wooden block of mass m resting on a rough horizontal table (coefficient of friction = μ) is pulled by a force F as shown in figure. The acceleration of the block moving horizontally is :



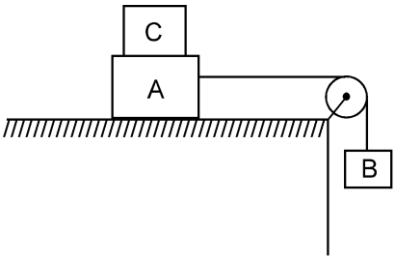
(1) $\frac{F\cos\theta}{m}$ (2) $\frac{\mu F \sin\theta}{M}$ (3) $\frac{F}{m}(\cos\theta + \mu\sin\theta) - \mu g$ (4) none

5. Two blocks m_1 = 4kg and m_2 = 2kg, connected by a weightless rod on a plane having inclination of 37^0. The coefficients of dynamic friction of m_1 and m_2 with the inclined plane are $\mu = 0.25$. Then the common acceleration of the two blocks and the tension in the rod are :



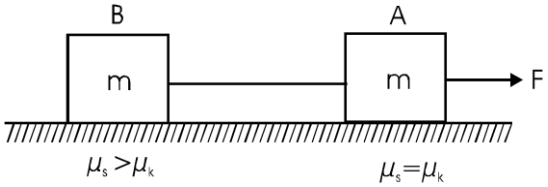
(1) 4 m/s^2, T = 0 (2) 2 m/s^2, T = 5 N
(3) 10 m/s^2 ,T = 10 N (4) 15 m/s^2, T = 9N

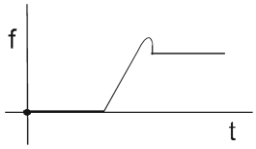
6. Two masses A and B of 10 kg and 5 kg respectively are connected with a string passing over a frictionless pulley fixed at the corner of a table as shown. The coefficient of static friction of A with table is 0.2. The minimum mass of C that may be placed on A to prevent it from moving is

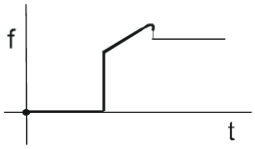


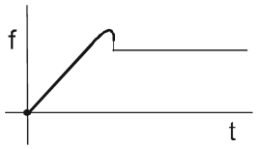
(1) 15 kg (2) 10 kg
(3) 5 kg (4) 12 kg

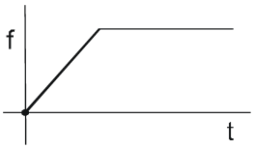
7. A force F = t is applied to block A as shown in figure. The force is applied at t = 0 seconds when the system was at rest and string is just straight without tension. Which of the following graphs gives the friction force between B and horizontal surface as a function of time 't'.



(1) 

(2) 

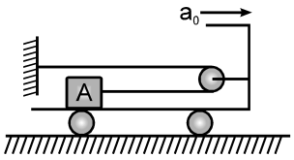
(3) 

(4) 

8. The upper portion of an inclined plane of inclination α is smooth and the lower portion is rough. A particle slides down from rest from the top and just comes to rest at the foot. If the ratio of the smooth length to rough length is m : n, the coefficient of friction is :

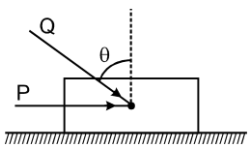
(1) $\left[\frac{m+n}{n}\right]\tan\alpha$ (2) $\left(\frac{m+n}{n}\right)\cot\alpha$ (3) $\left(\frac{m-n}{n}\right)\cot\alpha$ (4) $\frac{1}{2}$

9. Starting from rest. A flat car is given a constant acceleration a_o = 2 m/s^2. A cable is connected to a crate A of mass 50 kg as shown. Neglect the friction between floor and car wheels and mass of pulley. Calculate corresponding tension in the cable. The cofficient of friction between crate & floor of the car is μ = 0.3. The tension in cable is -



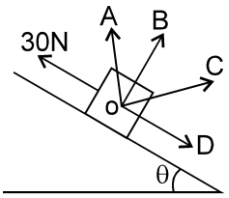
(1) 700 N
(2) 350 N
(3) 175 N
(4) 0

10. A block of mass m lying on a rough horizontal plane is acted upon by a horizontal force P and another force Q inclined at an angle θ to the vertical. The minimum value of coefficient of friction between the block and the surface for which the block will remain in equilibrium is:



(1) $\frac{P+Q\sin\theta}{mg+Q\cos\theta}$ (2) $\frac{P\cos\theta+Q}{mg-Q\sin\theta}$ (3) $\frac{P+Q\cos\theta}{mg+Q\sin\theta}$ (4) $\frac{P\sin\theta-Q}{mg-Q\cos\theta}$

11. A body of mass 10 kg lies on a rough inclined plane of inclination $\theta = \sin^{-1}\frac{3}{5}$ with the horizontal. When a force of 30 N is applied on the block parallel to & upward the plane, the total reaction by the plane on the block is nearly along:

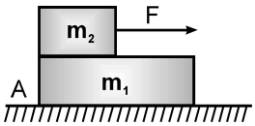


(1) OA (2) OB
(3) OC (4) OD

12. What is the minimum stopping distance for a vehicle of mass m moving with speed v along a level road. If the coefficient of friction between the tyres and the road is μ.

(1) $\frac{v^2}{2\mu g}$ (2) $\frac{2v^2}{\mu g}$ (3) $\frac{v^2}{\mu g}$ (4) none of these

13. Slab A is resting on a frictionless floor. Its mass is 35 kg. Another block of mass 7 kg is resting on it as shown in the diagram. The co-efficient of static friction between the block and slab is 0.5, while kinetic friction is 0.4. If a force of F N is applied to m_2, : ($g = 10\ m\,s^{-2}$)



The minimum value of force to cause m_2 to move with respect to m_1 is:

(1) 72 N (2) 42 N (3) 35 N (4) none

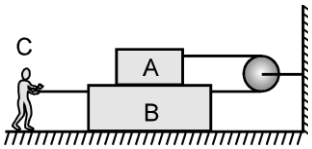
14. In above problem if $m_1 = 10$ kg, $m_2 = 40$ kg and applied force is 40 N, the acceleration of the block with respect to m_1 will be:

(1) zero (2) $0.5\ m\,s^{-2}$ (3) $2.5\ m\,s^{-2}$ (4) none

15. In problem number **(ii)** what will be the acceleration of the system?

(1) zero (2) $0.5\ m\,s^{-2}$ (3) $0.8\ m\,s^{-2}$ (4) none

16. In the figure $m_A = m_B = m_C = 60$ kg. The co-efficient of friction between C and ground is 0.5, B and ground is 0.3, A & B is 0.4. C is pulling the string with the maximum possible force without moving. Then tension in the string connected to A will be:



(1) 120 N (2) 60 N
(3) 100 N (4) zero

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion/Reasoning

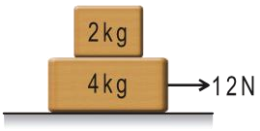
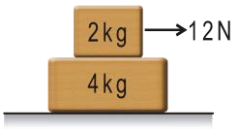
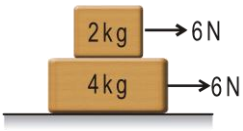
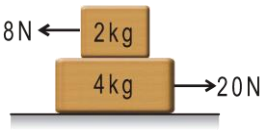
A-1. **STATEMENT-1 :** While drawing a line on a paper, friction force acts on paper in the same direction along which line is drawn on the paper.
STATEMENT-2 : Friction always opposes motion.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

A-2. **STATEMENT-1 :** A body is lying at rest on a rough horizontal surface. A person accelerating with acceleration $a\hat{i}$ (where a is positive constant and $\hat{i}$ is a unit vector in horizontal direction) observes the body. With respect to him, the block experiences a kinetic friction.
STATEMENT-2 : Whenever there is relative motion between the contact surfaces then kinetic friction acts.
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

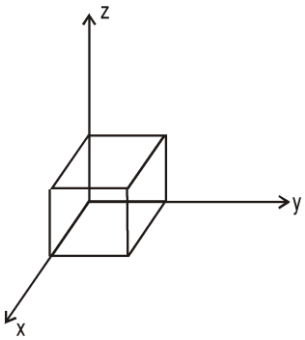
Section (B) : Match the column

B-1. Column II gives certain situations involving two blocks of mass 2 kg and 4 kg. The 4 kg block lies on a smooth horizontal table. There is sufficient friction between both the block and there is no relative motion between both the blocks in all situations. Horizontal forces act on one or both blocks as shown. Column I gives certain statement related to figures given in column II. Match the statements in column I with the figure in column II and indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in OMR.

Column I	**Column II**
(1) Magnitude of frictional force is maximum.	(p) 
(2) Magnitude of friction force is least.	(q) 
(3) Friction force on 2 kg block is towards right.	(r) 
(4) Friction force on 2 kg block is towards left.	(s) 

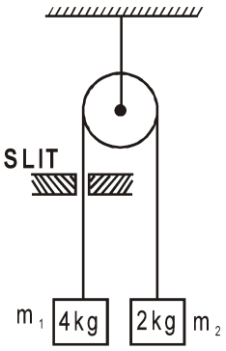
Section (C) : One or More Than One Options Correct

C-1. A solid cube of mass 5 kg is placed on a rough horizontal surface, in xy-plane as shown. The friction coefficient between the surface and the cube is 0.4. An external force $\vec{F} = 6\hat{i} + 8\hat{j} + 20\hat{k}$ N is applied on the cube.
(use g = 10 m/s^2)



(1) The block starts slipping over the surface
(2) The friction force on the cube by the surface is 10 N.
(3) The friction force acts in xy-plane at angle 127° with the positive x-axis in clockwise direction.
(4) The contact force exerted by the surface on the cube is $10\sqrt{10}$ N.

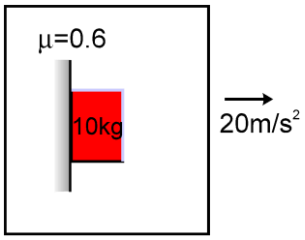
C-2. Two masses m_1 = 4 kg and m_2 = 2kg are connected with an inextensible, massless string that passes over a frictionless pulley and through a slit, as it moves. The string is vertical on both sides and the string on the left is acted upon by a constant friction force 10 N by the slit as it moves. (use g = 10 m/s^2)



(1) Acceleration of mass m_1 is $\frac{5}{3}$ m/s^2, downwards.
(1) Tension in the string is same throughout.
(3) Force exerted by the string on mass m_2 is $\frac{70}{3}$ N.
(4) If position of both the masses are interchanged, then 2kg mass moves up with an acceleration $\frac{10}{3}$ m/s^2.

C-3. The contact force exerted by one body on another body is equal to the normal force between the bodies. It can be said that :
(1) the surface must be frictionless
(2) the force of friction between the bodies is zero
(3) the magnitude of normal force equals that of friction
(4) It is possible that the bodies are rough and they do not slip on each other.

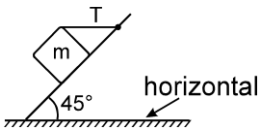
C-4. Car is accelerating with acceleration = 20 m/s^2. A box that is placed inside the car, of mass m = 10 kg is put in contact with the vertical wall of car as shown. The friction coefficient between the box and the wall is μ = 0.6.



(1) The acceleration of the box will be 20 m/sec^2
(2) The friction force acting on the box will be 100 N
(3) The contact force between the vertical wall and the box will be 100 $\sqrt{5}$ N
(4) The net contact force between the vertical wall and the box is only of electromagnetic in nature.

C-5. The force F_1 that is necessary to move a body up an inclined plane is double the force F_2 that is necessary to just prevent it from sliding down, then :
(1) $F_2 = w \sin(\theta - \varphi) \sec\varphi$ (2) $F_1 = w \sin(\theta - \varphi) \sec\varphi$
(3) $\tan\varphi = 3\tan\theta$ (4) $\tan\theta = 3\tan\varphi$
Where φ = angle of friction,
θ = angle of inclined plane
w = weight of the body

C-6. A block of mass 15 kg is resting on a rough inclined plane as shown in figure. The block is tied up by a horizontal string which has a tension of 50 N. The coefficient of friction between the surfaces of contact is (g = 10 m/s^2)



(1) 1/2 (2) 2/3
(3) 3/4 (4) 1/4

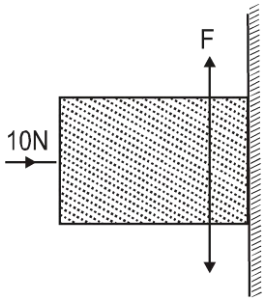
Exercise-3

*** Marked Questions may have more than one correct option.**

Marked Questions can be used as Revision Questions.

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2. The weight of the block is : **[JEE (Main) 2003, 4/300]**



(1) 20 N
(2) 50 N
(3) 100 N
(4) 2 N

2. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10s. Then the coefficient of friction is : **[JEE (Main) 2003, 4/300]**

(1) 0.02 (2) 0.03 (3) 0.06 (4) 0.01

3. A block rests on a rough inclined plane making an angle of 30º with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, the mass of the block (in kg) is (take g = 10 m/s^2) : **[JEE (Main) 2004, 4/300]**

(1) 2.0 (2) 4.0 (3) 1.6 (4) 2.5

4. A smooth block is released at rest on a 45º incline and then slides a distance d. The time taken to slide is n times as much to slide on rough incline than on a smooth incline. The coefficient of friction is- **[JEE (Main) 2005, 4/300]**

(1) $\mu_s = 1-\frac{1}{n^2}$ (2) $\mu_s = \sqrt{1-\frac{1}{n^2}}$ (3) $\mu_k = 1-\frac{1}{n^2}$ (4) $\mu_k = \sqrt{1-\frac{1}{n^2}}$

5. The upper half of an incline plane with inclination φ is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the the bottom if the coefficient of friction for the lower half is given by **[JEE (Main) 2005, 4/300]**

(1) 2 tan φ (2) tan φ (3) 2 sin φ (4) 2 cos φ

6. Consider a car moving on a straight road with a speed of 100 m/s. The distance at which car can be stopped is [μ_k = 0.5] **[JEE(Main)-2005, 4/300]**

(1) 100 m (2) 400 m (3) 800 m (4) 1000 m

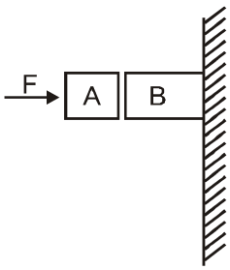
7. The minimum force required to start pushing a body up a rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle θ from the horizontal such that tan $\theta = 2\mu$ then the ratio $\frac{F_1}{F_2}$ is : **[JEE(Main)-2011, 4/120, –1]**

(1) 1 (2) 2 (3) 3 (4) 4

8. A block of mass m is placed on a surface with a vertical cross section given by $y = \frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is : **[JEE(Main)-2014, 4/120, –1]**

(1) $\frac{1}{6}$ m (2) $\frac{2}{3}$ m (3) $\frac{1}{3}$ m (4) $\frac{1}{2}$ m

9. Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks is 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is :

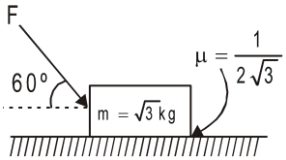


[JEE(Main)-2015; 4/120, –1]

(1) 100N (2) 80N
(3) 120N (4) 150N

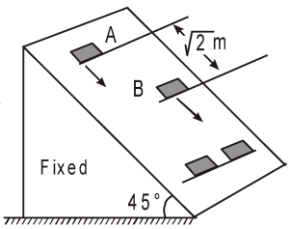
PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. What is the maximum value of the force F such that the block shown in the arrangement, does not move : **[JEE 2003 (Screening); 3/90]**



(A) 20 N (B) 10 N
(C) 12 N (D) 15 N

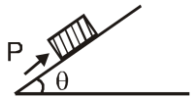
2. Two blocks A and B of equal masses are sliding down along straight parallel lines on an inclined plane of 45°. Their coefficients of kinetic friction are $\mu_A = 0.2$ and $\mu_B = 0.3$ respectively. At t = 0, both the blocks are at rest and block A is $\sqrt{2}$ meter behind block B. The time and distance from the initial position where the front faces of the blocks come in line on the inclined plane as shown in figure. (Use g = 10 ms^{-2}.) **[JEE 2004 (Scr.) 3/84]**

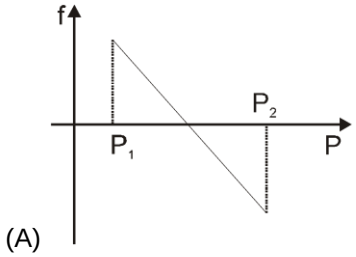


(A) 2s, $8\sqrt{2}$ m (B) $\sqrt{2}$ s, 7m (C) $\sqrt{2}$ s, $7\sqrt{2}$ m (D) 2s, $7\sqrt{2}$ /m

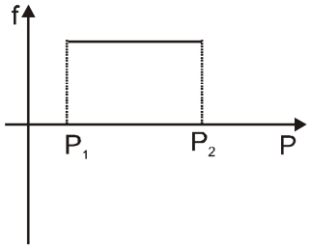
3. **STATEMENT -1**
It is easier to pull a heavy object than to push it on a level ground. **[JEE 2008, 3/163, –1]**
STATEMENT -2
The magnitude of frictional force depends on the nature of the two surfaces in contact.
(A) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 **is** a correct explanation for STATEMENT -1
(B) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 **is NOT** a correct explanation for STATEMENT -1
(C) STATEMENT -1 is True, STATEMENT -2 is False
(D) STATEMENT -1 is False, STATEMENT -2 is True.

4. A block of mass m is on inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and tanθ > μ. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = mg(\sin\theta + \mu\cos\theta)$, the frictional force f versus P graph will look like **[JEE 2010, 3/163, –1]**

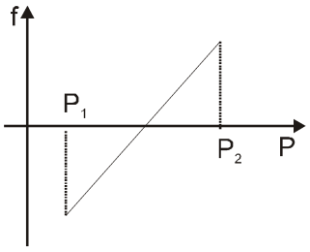




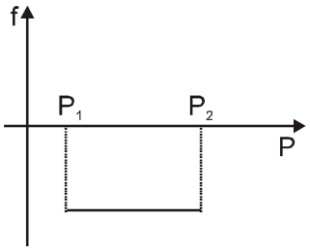
(A)



(B)

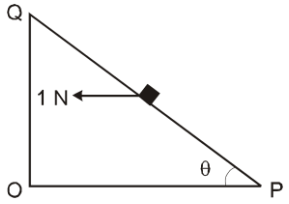


(C)



(D)

5.* A small block of mass of 0.1 kg lies on a fixed inclined plane PQ which makes an angle θ with the horizontal. A horizontal force of 1 N on the block through its center of mass as shown in the figure. The block remains stationary if (take g = 10 m/s^2) **[IIT-JEE-2012, Paper-1; 4/70]**



(A) θ = 45°

(B) θ > 45° and a frictional force acts on the block towards P.

(C) θ > 45° and a frictional force acts on the block towards Q.

(D) θ < 45° and a frictional force acts on the block towards Q.

Answers

EXERCISE - 1

Section (A)

A-1.	(3)	**A-2.**	(3)	**A-3.**	(4)
A-4	(2)	**A-5.**	(4)		

Section (B)

B-1	(1)	**B-2.**	(3)	**B-3.**	(1)
B-4.	(2)	**B-5.**	(4)	**B-6.**	(1)
B-7.	(4)	**B-8.**	(3)	**B-9.**	(1)
B-10.	(1)	**B-11.**	(1)	**B-12.**	(1)
B-13.	(1)				

Section (C)

C-1.	(1)	**C-2.**	(1)	**C-3.**	(4)

EXERCISE – 2

PART – I

1.	(3)	**2.**	(4)	**3.**	(2)
4.	(3)	**5.**	(1)	**6.**	(1)
7.	(1)	**8.**	(1)	**9.**	(2)
10.	(1)	**11.**	(1)	**12.**	(1)
13.	(2)	**14.**	(1)	**15.**	(3)
16.	(4)				

PART - II

Section (A)

A-1.	(3)	**A-2.**	(4)

Section (B)

B-1. (1 → s) (2→ r) (3 → p, s) (4 → q, r)

Section (C)

C-1.	(2, 3 ,4)	**C-2.**	(1, 3)	**C-3.**	(2, 4)
C-4.	(1, 2, 3, 4)	**C-5.**	(1, 4)	**C-6.**	(1, 2, 3)

EXERCISE – 3

PART – I

1.	(4)	**2.**	(3)	**3.**	(1)
4.	(3)	**5.**	(1)	**6.**	(4)
7.	(3)	**8.**	(1)	**9.**	(3)

PART – II

1.	(A)	**2.**	(A)	**3.**	(B)
4.	(A)	**5.**	(A, C)		