DPP - Daily Practice Problems

Name : ______ Date : ______

Start Time : ______ End Time : ______

PHYSICS 11

SYLLABUS : LAWS OF MOTION-3 (Friction)

Max. Marks : 112 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 28 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.20) : There are 20 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A body of mass 400 g slides on a rough horizontal surface. If the frictional force is 3.0 N, the angle made by the contact force on the body with the vertical will be

(a) 37° (b) 53° (c) 63° (d) 27°

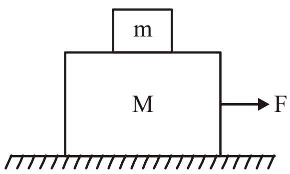
Q.2 In the above question, the magnitude of the contact force is
($g = 10\ m/s^2$)

(a) 3.0 N (b) 4.0 N (c) 5.0 N (d) 7.0 N

Q.3 The coefficient of static friction between a block of mass m and an inclined plane is $\mu_s = 0.3$. What can be the maximum angle θ of the inclined plane with the horizontal so that the block does not slip on the plane?

(a) $\tan^{-1}(0.1)$ (b) $\tan^{-1}(0.2)$
(c) $\tan^{-1}(0.3)$ (d) $\tan^{-1}(0.4)$

Q.4 The coefficient of static friction between the two blocks shown in figure is μ and the table is smooth. What maximum horizontal force F can be applied to the block of mass M so that the blocks move together?



(a) $\mu g (M + m)$ (b) $\mu g (M - m)$
(c) $2\mu g (M + m)$ (d) $\mu g (M + 2m)$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

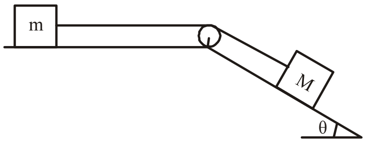
Space for Rough Work

Q.5 Block A weighs 4 N and block B weighs 8 N. The coefficient of kinetic friction is 0.25 for all surfaces. Find the force F to slide B at a constant speed when A rests on B and moves with it.
(a) 2N (b) 3N (c) 1N (d) 5N

Q.6 In the above question, find the force F to slide B at a constant speed when A is held at rest.
(a) 2N (b) 3N (c) 1N (d) 4N

Q.7 In the above question, find the force F to slide B at a constant speed when A and B are connected by a light cord passing over a smooth Pulley.
(a) 2N (b) 3N (c) 1N (d) 5N

Q.8 Find the maximum value of M/m in the situation shown in figure so that the system remains at rest. Friction coefficient at both the contacts is μ.



(a) $\dfrac{\mu}{\sin\theta-\mu\cos\theta}$ (b) $\dfrac{2\mu}{\sin\theta-\mu\cos\theta}$

(c) $\dfrac{\mu}{\sin\theta+\mu\cos\theta}$ (d) $\dfrac{\mu}{\cos\theta-\mu\sin\theta}$

Q.9 A block placed on a horizontal surface is being pushed by a force F making an angle θ with the vertical, if the coefficient of friction is μ, how much force is needed to get the block just started?

(a) $\dfrac{\mu}{\sin\theta-\mu\cos\theta}$ (b) $\dfrac{2\mu}{\sin\theta-\mu\cos\theta}$

(c) $\dfrac{\mu}{\sin\theta+\mu\cos\theta}$ (d) $\dfrac{\mu}{\cos\theta-\mu\sin\theta}$

Q.10 Assuming the length of a chain to be L and coefficient of static friction μ. Compute the maximum length of the chain which can be held outside a table without sliding.

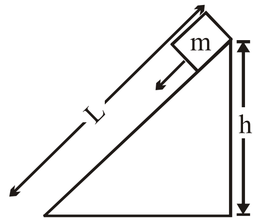
(a) $\dfrac{2\mu L}{1+\mu}$ (b) $\dfrac{\mu L}{1-\mu}$ (c) $\dfrac{\mu L}{1+\mu}$ (d) $\dfrac{3\mu L}{1+\mu}$

Q.11 If the coefficient of friction between an insect and bowl is μ and the radius of the bowl is r, find the maximum height to which the insect can crawl in the bowl.

(a) $R\left[1+\dfrac{1}{\sqrt{(\mu^2+1)}}\right]$ (b) $R\left[1-\dfrac{1}{\sqrt{(\mu^2-1)}}\right]$

(c) $R\left[1-\dfrac{2}{\sqrt{(\mu^2+1)}}\right]$ (d) $R\left[1-\dfrac{1}{\sqrt{(\mu^2+1)}}\right]$

Q.12 A body of mass m is released from the top of a rough inclined plane as shown in figure. If the frictional force be F, then body will reach the bottom with a velocity



(a) $\sqrt{\dfrac{2}{m}(mgh-FL)}$ (b) $\sqrt{\dfrac{1}{m}(mgh-FL)}$

(c) $\sqrt{\dfrac{2}{m}(mgh+FL)}$ (d) None of these

Q.13 A block of mass 2 kg is placed on the floor. The coefficient of static friction is 0.4. A force F of 2.5 N is applied on the block, as shown. Calculate the force of friction between the block and the floor. ($g = 9.8\ ms^{-2}$)
(a) 2.5 N (b) 25 N (c) 7.84 N (d) zero

Q.14 A block is kept on a horizontal table. The table is undergoing simple harmonic motion of frequency 3 Hz in a horizontal plane. The coefficient of static friction between the block and the table surface is 0.72. Find the maximum amplitude of the table at which the block does not slip on the surface ($g = 10\ ms^{-2}$)
(a) 0.01 m (b) 0.02 m (c) 0.03 m (d) 0.04 m

Q.15 Two cars of unequal masses use similar tyres. If they are moving at the same initial speed, the minimum stopping distance -
(a) is smaller for the heavier car
(b) is smaller for the lighter car
(c) is same for both cars
(d) depends on the volume of the car

RESPONSE GRID					
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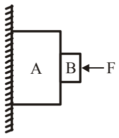
	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ
	15. ⓐⓑⓒⓓ				

Space for Rough Work

Q.16 Consider the situation shown in figure. The wall is smooth but the surfaces of A and B in contact are rough in equilibrium the friction on B due to A –



(a) is upward
(b) is downward
(c) is zero
(d) the system cannot remain in equilibrium

Q.17 A block is placed on a rough floor and a horizontal force F is applied on it. The force of friction f by the floor on the block is measured for different values of F and a graph is plotted between them –
(i) The graph is a straight line of slope 45°
(ii) The graph is straight line parallel to the F axis
(iii) The graph is a straight line of slope 45° for small F and a straight line parallel to the F-axis for large F.
(iv) There is small kink on the graph
(a) iii, iv (b) i, iv (c) i, ii (d) i, iii

Q.18 The contact force exerted by a body A on another body B is equal to the normal force between the bodies. We conclude that -
(i) the surfaces must be smooth
(ii) force of friction between two bodies may be equal to zero
(iii) magnitude of normal reaction is equal to that of friction
(iv) bodies may be rough
(a) ii, iv (b) i, ii (c) iii, iv (d) i, iv

Q.19 It is easier to pull a body than to push, because -
(a) the coefficient of friction is more in pushing than that in pulling
(b) the friction force is more in pushing than that in pulling
(c) the body does not move forward when pushed
(d) None of these

Q.20 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 -
(a) μg (b) μ/g (c) $\mu^2 g$ (d) μg^2

DIRECTIONS (Q.21-Q.23) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :
(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.21 Choose the correct statements –
(1) Kinetic friction is lesser than limiting friction.
(2) In rolling the surfaces at contact do not rub each other.
(3) If a body is at rest and no pulling force is acting on it, force of friction on it is zero.
(4) Kinetic friction is greater than limiting friction.

Q.22 Choose the correct statements –
(1) Force of friction is partically independent of microscopic area of surface in contact and relative velocity between them. (if it is not high)
(2) Normally with increase in smoothness friction decreases. But if the surface area are made too smooth by polishing and cleaning the bonding force of adhesion will increase and so the friction will increase resulting in 'Cold welding'
(3) Friction is a non conservative force, i.e. work done against friction is path dependent.
(4) Force of fricton depends on area

Q.23 Choose the correct options –
(1) Friction always opposes the motion
(2) Friction may opposes the motion
(3) If the applied force is increased the force of static friction remains constant.
(4) If the applied force is increased the force of static friction also increases upto limiting friction.

DIRECTIONS (Q.24-Q.26) : Read the passage given below and answer the questions that follows :

A block of mass 1 kg is placed on a rough horizontal surface. A spring is attached to the block whose other end is joined to a rigid wall, as shown in the figure. A horizontal force is applied on the block so that it remains at rest while the spring is elongated by x.

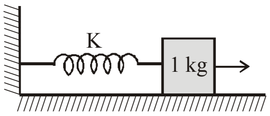
RESPONSE GRID					
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ
	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ		

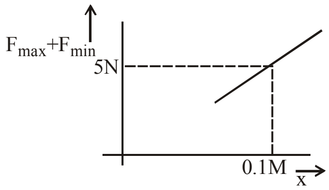
Space for Rough Work

$x \geq \frac{\mu mg}{k}$. Let F_{max} and F_{min} be the maximum and minimum values of force F for which the block remains a equilibrium. For a particular x,

$$F_{max} - F_{min} = 2N.$$

Also shown is the variation of $F_{max} + F_{min}$ versus x, the elongation of the spring.





Q.24 The coefficient of friction between the block and the horizontal surface is –

(a) 0.1 (b) 0.2
(c) 0.3 (d) 0.4

Q.25 The spring constant of the spring is –

(a) 25 N/m (b) 20 N/m
(c) 2.5 N/m (d) 50 N/m

Q.26 The value of F_{min}, if x = 3 cm. is –

(a) 0 (b) 0.2 N
(c) 5N (d) 1N

DIRECTIONS (Q. 27-Q.28) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(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 False, Statement-2 is True.
(d) Statement -1 is True, Statement-2 is False.

Q.27 A solid sphere and a hollow sphere of same mass *M* and same radius *R* are released from the top of a rough inclined plane. Friction coefficient is same for both the bodies. If both bodies perform imperfect rolling, then

Statement - 1 : Work done by friction for the motion of bodies from top of incline to the bottom will be same for both the bodies.

Statement - 2 : Force of friction will be same for both the bodies.

Q.28 **Statement - 1 :** Maximum value of friction force between two surfaces is $\mu \times$ normal reaction.

where μ = coefficient of friction between surfaces.

Statement - 2 : Friction force between surfaces of two bodies is always less than or equal to externally applied force.

RESPONSE GRID	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 11 - PHYSICS			
Total Questions	28	Total Marks	112
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	26	Qualifying Score	42
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

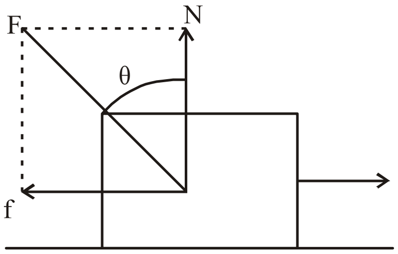
Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

11

(1) **(a)** Let the contact force on the block by the surface be F which makes an angle θ with the vertical. The component of F perpendicular to the contact surface is the normal force N and the component F parallel to the surface is the friction f. As the surface is horizontal, N is vertically upward. For vertical equilibrium



$N = Mg = (0.400)(10) = 4.0\text{ N}$

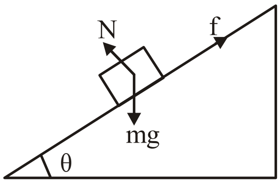
The frictional force is $f = 3.0\text{ N}$

$$\tan\theta = \frac{f}{N} = \frac{3}{4} \Rightarrow \theta = \tan^{-1}(3/4) = 37^o$$

(2) **(c)** The magnitude of the contact force is

$$F = \sqrt{N^2 + f^2} = \sqrt{(4)^2 + (3)^2} = 5.0\text{ N}$$

(3) **(c)** The forces on the block are



(i) the weight mg downward by the earth

(ii) the normal contact force N by the incline, and

(iii) the friction f parallel to the incline up the plane, by the incline.

As the block is at rest, these forces should add up to zero. Also since θ is the maximum angle to prevent slipping, this is a case of limiting equilibrium and so

$$f = \mu_S N$$

Taking component perpendicular to the Incline,

$N - mg\cos\theta = 0 \Rightarrow N = mg\cos\theta$ .... (1)

Taking component parallel to the incline

$f - mg\sin\theta = 0 \Rightarrow f = mg\sin\theta$ .... (2)

$\therefore\ \mu_S N = mg\sin\theta$

Dividing (2) by (1) $\mu_S = \tan\theta$

$\theta = \tan^{-1}\mu_S = \tan^{-1}(0.3)$

(4) **(a)** When the maximum force F is applied, both the blocks move together towards right. The only horizontal force on the upper block of mass m is that due to the friction by the lower block of mass M. Hence this force on m should be towards right. The force of friction on M by m should be towards left by Newton's third law. As we are talking of the minimum possible force F that can be applied, the friction is limiting and hence

$f = \mu N$, where N is normal force.

in the vertical direction, there is no acceleration

$\therefore\ N = mg$

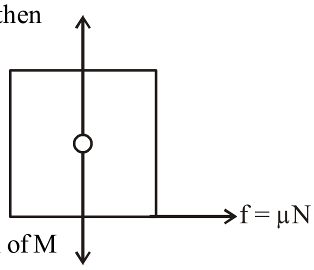
in the horizontal direction,

let the acceleration be a, then

$\mu N = ma$

$\mu mg = ma$

$a = \mu g$



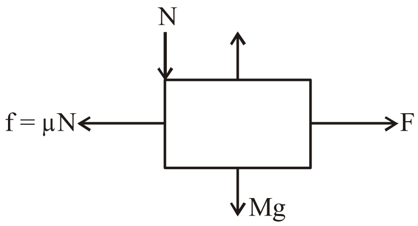
Next consider the motion of M

The equation of motion is

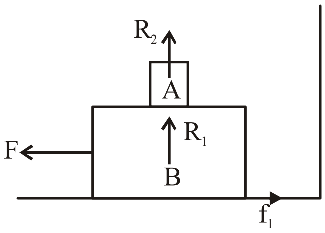
$F = \mu N = Ma$

$F - \mu mg = M\mu g$

$F = \mu g(M + m)$

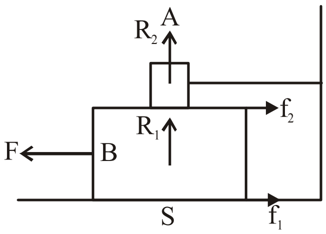


(5) **(b)** When A moves with B the force opposing the motion is the only force of friction between B and S the horizontal and velocity of the system is constant



$F = f_1 = \mu R_1 = 0.25(4 + 8) = 3\text{N}$

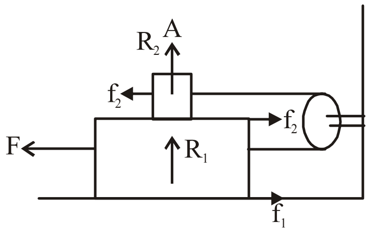
(6) **(d)** When A is held stationary the friction opposing the motion is between A and B and B and S. So



$F = \mu R_1 + \mu R_2 = 3 + 0.25(4)$

$F = 3 + 1 = 4\text{ N}$

(7) **(d)** In this situation for dynamic equilibrium of B



$F = \mu R_1 + \mu R_2 + T$ ..... (1)

While for the uniform motion of A

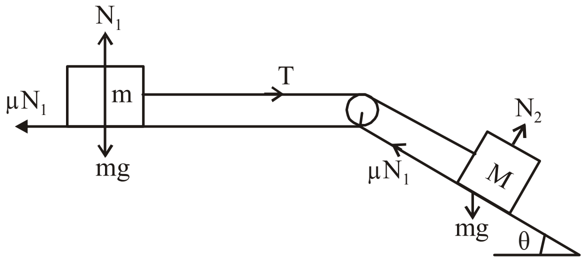
$T = \mu R_2$ .... (2)

Substituting T from Equation (2) in (1) we get

$F = \mu R_1 + 2\mu R_2 = 3 + 2 \times 1 = 5N$

(8) **(a)** Figure shows the forces acting on the two blocks. As we are looking for the maximum value of M/m, the equilibrium is limiting. Hence the frictional forces are equal to μ times corresponding normal force.

Equilibrium of the block m gives



$T = \mu N_1$ and $N_1 = mg \Rightarrow T = \mu mg$ .... (1)

Next consider the equilibrium of the block M. Taking components parallel to the incline

$T + \mu N_2 = Mg \sin\theta$

Taking components normal to the Incline

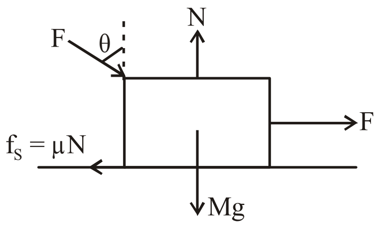
$N_2 = Mg \cos\theta$

These give $T = Mg(\sin\theta - \mu\cos\theta)$ ...... (2)

From (1) and (2) $\mu mg = Mg(\sin\theta - \mu\cos\theta)$

$$\frac{M}{m} = \frac{\mu}{\sin\theta - \mu\cos\theta}$$

(9) **(a)** The situation is shown in figure in the limiting equilibriums the frictional force f will be equal to μN.



For horizontal equilibrium

$F \sin\theta = \mu N$

For vertical equilibrium

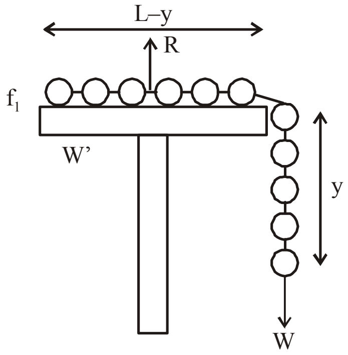
$F \cos\theta + mg = N$

Eliminating N from these equations

$F \sin\theta = \mu F \cos\theta + \mu mg$

$$F = \frac{\mu}{(\sin\theta - \mu\cos\theta)}$$

(10) **(c)** If y is the maximum length of chain which can be hang out side the table without sliding, then for equilibrium of the chain, the weight of hanging part must be balanced by force of friction from the portion on the table



$W = f_L$ .... (1)

But from figure $W = \frac{M}{L} y g$ and

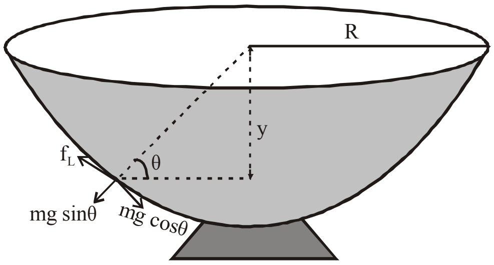
$$R = W' = \frac{M}{L}(L - y)g$$

So that $f_L = \mu R = \frac{\mu M}{L}(L - y)g$

Substituting these values of W and f_L in equation (1) we get

$$\frac{M}{L} yg = \mu \frac{M}{L}(L - y)g$$

(11) **(d)** The insect will crawl up the bowl till the component of its weight along the bowl is balanced by limiting friction so, resolving weight perpendicular to the bowl and along the bowl we get



R = mg sin θ

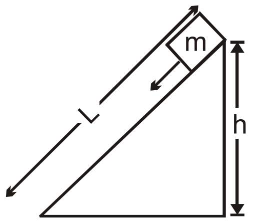
$f_L = mg \cos\theta$

$$\tan\theta = \frac{R}{f_L} = \frac{R_1}{\mu R_1} = \frac{1}{\mu} \; ; \; \frac{y}{\sqrt{R^2 - y^2}} = \frac{1}{\mu}$$

$$\mu^2 y^2 = R^2 - y^2 \; ; \; y = \frac{R_1}{\sqrt{\mu^2 + 1}}$$

$$\text{So, } h = R - y = R - \frac{R}{\sqrt{\mu^2 + 1}} = R\left[1 - \frac{1}{\sqrt{(\mu^2 + 1)}}\right]$$

(12) **(a)**



Loss in P.E. in reaching the bottom = mgh and gain in K.E.

reaching the bottom = $\frac{1}{2}mv^2$

where v is velocity gained by the body in reaching the bottom

$\therefore$ Net loss in energy = $mgh - \frac{1}{2}mv^2$

work done against friction = FL

$\therefore mgh - \frac{1}{2}mv^2 = FL\ ;\ v = \sqrt{\frac{2}{m}(mgh - FL)}$

(13) **(a)** Let R be the normal reaction on the block exerted by the floor. The limiting (maximum) force of static friction is
$f_s = \mu_s R = \mu_s mg$
$= 0.4 \times 2kg \times 9.8\ ms^{-2} = 7.84\ N$
The applied force F is 2.5 N, that is less than the limiting frictional force. Hence under the force F, the block does not move. So long the block does not move, the (adjustable) frictional force is always equal to the applied force. Thus the frictional force is 2.5 N.

(14) **(b)** When the block does not slip on the table surface, it performs simple harmonic motion along with the table.
$x = a \sin \omega t$
The instantaneous acceleration of the block is

$$\frac{d^2x}{dt^2} = -\omega^2 a \sin \omega t$$

The maximum acceleration is $\left|\frac{d^2x}{dt^2}\right|_{max} = \omega^2 a$

The maximum force on the block is $f_{max} = m\omega^2 a$ where m is its mass. The frictional force on the block is μmg. since the block is at rest with respect to the table, we have $m\omega^2 a = \mu mg$
$(2\pi f)^2 a = \mu g$

$$\Rightarrow a = \frac{\mu g}{4\pi^2 f^2} = \frac{0.72 \times 10}{4 \times (3.14)^2 \times 3^2} = 0.02\ m$$

(15) **(c)** Stopping distance is independent on mass.

(16) **(a)** (i) coefficient of static friction is always greater than the coefficient of kinetic friction
(ii) limiting friction is always greater than the kinetic friction
(iii) limiting friction is never less than static friction

(17) **(d)** The system can not remain in equilibrium

(18) **(a)** (i) In the force applied v/s friction graph : The graph is a straight line of slope 45° for small F and a straight line parallel to the F-axis for large F.
(ii) There is small kink on the graph

(19) **(a)** (i) force of friction between two bodies may be equal to zero
(ii) bodies may be rough

(20) **(b)** It is easier to pull a body than to push, because the friction force is more in pushing than that in pulling

(21) **(a)** $ma = \mu mg$
$a = \mu g$

(22) **(a)**
(1) Kinetic friction is lesser than limiting friction.
(2) In rolling the surfaces at contact do not rub each other.
(3) If a body is at rest and no pulling force is acting on it, force of friction on it is zero.

(23) **(a)**
(1) Force of friction is partically independent of microscopic area of surface in contact and relative velocity between them. (if it is not high)
(2) Normally with increase in smoothness friction decreases. But if the surface area are made too smooth by polishing and cleaning the bonding force of adhesion will increase and so the friction will increase resulting in 'Cold welding'
(3) Friction is a non conservative force, i.e. work done against friction is path dependent.

(24) **(c)**
(2) Friction may opposes the motion
(4) If the applied force is increased the force of static friction also increases upto limiting friction.

(25) (a), (26) (a), (27) (a).
$F_{max} = kx + \mu mg$
$F_{min} = kx - \mu mg$
$\therefore\ F_{max} + F_{min} = 2\mu mg$
or $2 = 2\mu 10$
$\therefore\ \mu = 0.1$
$F_{max} + F_{min} = 2kx$ .... (1)
From graph, $F_{max} + F_{min} = 5$ and $x = 0.1$
Putting in eq. (1)
$t = 2k(0.1)\ ;\ k = 25\ N/m$
When $x = 0.03$
$kx = 25 \times 0.03 = 0.75\ N$, which is less than μmg
$= 0.1 \times 10 = 1N$
$\therefore$ The block will be at rest, without applying force F.

(28) **(b)** It is easier to pull a heavy object than to push it on a level ground. Statement-1 is true. This is because the normal reaction in the case of pulling is less as compared by pushing. ($f = \mu N$). Therefore the functional force is small in case of pulling.
Statement-2 is true but is not the correct explanation of statement-1.

(29) **(c)** W = (force) × (displacement of point of application)

(30) **(d)** Statement – 2 is false because friction force may be more than applied force when body is retarding and external force is acting on body.