PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 29

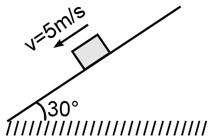
Total Marks : 26

Max. Time : 28 min.

Topics : Friction, Newtons's Law of Motion

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.3	(3 marks, 3 min.)	[9, 9]
Subjective Questions ('–1' negative marking) Q.4 to Q.5	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks, 3 min.)	[9, 9]

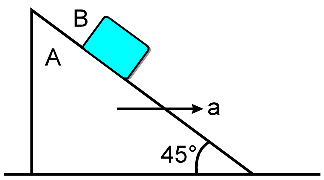
1. A particle of mass 5 kg is moving on rough fixed inclined plane with constant velocity of 5 m/s as shown in the figure. Find the friction force acting on a body by plane.



(A) 25 N (B) 20 N
(C) 30 N (D) none of these

2. A block of mass 4 kg is kept on ground. The co-efficient of friction between the block and the ground is 0.80. An external force of magnitude 30 N is applied parallel to the ground. The resultant force exerted by the ground on the block is:
(A) 40 N (B) 30 N (C) 0 N (D) 50 N

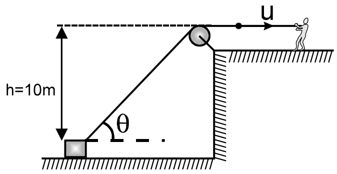
3. If the coefficient of friction between A and B is μ, the maximum horizontal acceleration of the wedge A for which B will remain at rest w.r.t the wedge is :



(A) μg (B) $g\left(\frac{1+\mu}{1-\mu}\right)$

(C) $\frac{g}{\mu}$ (D) $g\left(\frac{1-\mu}{1+\mu}\right)$

4. In the figure shown, a person pulls a light string with a constant speed u = 10 m/s. The other end of the string is tied to a very small block which moves on a smooth horizontal surface. Find the angle 'θ' when the block 3leaves the surface. Take g = 10 m/s^2.



5. Answer the following briefly. (Answer should not be of more than one or two line)

(i) Can friction coefficient be greater than unity?

(ii) Why is friction force Nonconservative force?

(iii) Can friction do positive work?

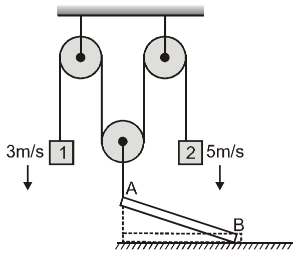
(iv) Is earth an inertial frame?

(v) Greater force is required to make the body move than to keep it moving, hence we can say that static friction is always greater than kinetic friction. Comment on it.

(vi) Lesser force is required to pull a lawn mower than to push it. Why?

COMPREHENSION

A meter stick AB of length 1 meter rests on a frictionless floor in horizontal position with end A attached to the string as shown. Assume that string connecting meter stick with pulley always remains vertical.



6. If blocks 1 and 2 are given constant speeds as shown then the distance moved by end B over the floor in the period for which speed of B is less than A.

(A) $\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$ m (B) $\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$ m (C) $\frac{1}{\sqrt{2}}$ m (D) $\frac{1}{2}$ m

7. Time taken to cover the distance in above part is :

(A) $\left(\frac{\sqrt{2}+1}{4\sqrt{2}}\right)$ sec (B) $\left(\frac{\sqrt{2}-1}{4\sqrt{2}}\right)$ sec (C) $\frac{1}{4\sqrt{2}}$ sec (D) $\frac{1}{8}$ sec

8. Minimum magnitude of relative velocity of A with respect to B during the motion specified in question 5 is :

(A) 2 m/s (B) 4 m/s (C) 6 m/s (D) None of these

Answers Key

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1. (A) **2.** (D) **3.** (B) **4.** θ =

5. (i) yes (ii) depends upon path (iii) yes (iv) no
(v) limiting friction needs to be overcome to make body move
(vi) N is larger

6. (B) **7.** (C) **8.** (B)

Hint & Solutions

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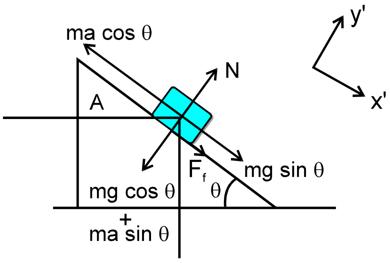
1. Sol. $f_k = \mu_k N = \mu_k \, mg \cos 30^0 = mg \sin 30^0$

$= 5\,(10)\left(\frac{1}{2}\right) \Rightarrow f_k = 25\text{ N}$

2. $N = mg = 40$
$(f_s)_{max} = \mu N = (0.8)\,(40) = 32$
f_s = ext. force = 30
$R^2 = N^2 + f_s^{\,2} = (50)^2 \therefore \quad R = 50\text{ N}.$

3. FBD of block B w.r.t. wedge A , for maximum 'a' :

Perpendicular to wedge :
$\Sigma f_{y'} = (mg \cos\theta + m\,a \sin\theta - N) = 0.$
and $\Sigma f_{x'} = mg \sin\theta + \mu N - ma\cos\theta = 0$ (for maximum a)



$\Rightarrow mg\sin\theta + \mu(mg\cos\theta + ma\sin\theta) - ma\cos\theta = 0$

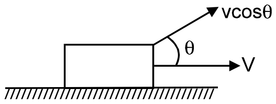
$\Rightarrow a = \dfrac{(g\sin\theta + \mu g\cos\theta)}{\cos\theta - \mu\sin\theta}$

for $\theta = 45^o$

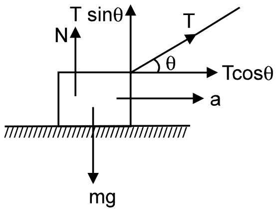
$a = g\left(\dfrac{\tan 45^o + \mu}{\cot 45^o - \mu}\right)$; $a = g\left(\dfrac{1+\mu}{1-\mu}\right)$ **Ans.**

4. By constraint velocity component of block along the string should be u

$\Rightarrow$ v cos θ = u or v = u sec θ ...(1)



from (1) $a = \frac{dv}{dt} = u \sec\theta \tan\theta \frac{d\theta}{dt}$ ...(2)



Initially when block is at a large distance θ is a small component of T in vertical direction is very small. As block comes nearer and nearer. T sin θ increases and N decreases.

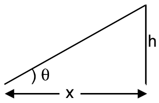
When T sinθ = mg then block just loses contact with the ground

so T sinθ = mg ....(3)

T cos θ = ma ....(4)

(3) & (4) $\Rightarrow$

a tan θ = g ....(5)



also, x = h cot θ

$$\frac{dx}{dt} = -h\,\text{cosec}^2\theta \frac{d\theta}{dt}$$

$\Rightarrow -v = -h\text{cosec}^2\theta \frac{d\theta}{dt}$ [as x is decreasing $\frac{dx}{dt}$ = – v]

or $\frac{u\sec\theta}{h\,\text{cosec}^2\theta} = \frac{d\theta}{dt}$ ...(using (1) ...(6)

using (2) , (5) and (6) we get

$$u \sec\theta \tan\theta \left(\frac{u\sec\theta}{h\,\text{cosec}^2\theta}\right) \tan\theta = g$$

putting values of u, h & g we get.

$\tan^4\theta = 1 \Rightarrow \theta =$

Ans. θ =

5. **(i) yes**

(ii) depends upon path

(iii) yes

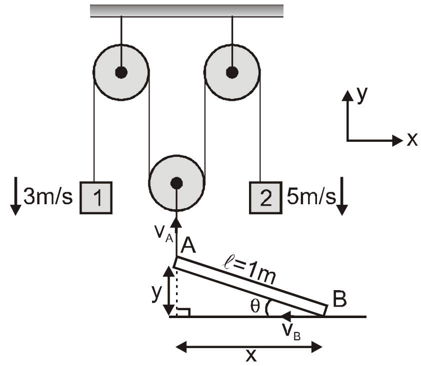
(iv) no

(v) limiting friction needs to be overcome to make body move

(vi) tension increases

(vii) N is larger]

6.



for any angle 'θ'

$x^2 + y^2 = \ell^2$

$\therefore \quad 2xx' + 2yy' = 0$

$\therefore \quad x(-v_B) + y(v_A) = 0$ i.e. $v_B = v_A \tan\theta$

or $\quad v_B = 4\tan\theta$ ...(i)

[as $v_A = \frac{3+5}{2} = 4$ m/s]

from $v_B = v_A \tan\theta$

we can see that $v_B < v_A$ for $0 \le \theta \le \frac{\pi}{4}$

$\therefore$ from $\theta = 0$ to $\theta = \frac{\pi}{4}$

distance moved by 'B' is

$$d = 1 - x = 1 - \frac{1}{\sqrt{2}} = \left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$$

[as $x = \frac{1}{\sqrt{2}}$ at $\theta = \frac{\pi}{4}$]

7. $t = \dfrac{x}{v_A} = \dfrac{1}{4\sqrt{2}}$ sec

8. $v_A = 4\hat{j}$ m/s and $v_B = (-4\tan\theta\,\hat{i})$ m/s

$\therefore \quad v_{AB} = (4\tan\theta\ \hat{\ } + 4\hat{j})$ m/s

$\therefore \quad v_{AB} = 4\sqrt{1+\tan^2\theta} = \dfrac{4}{\cos\theta}$

$\therefore \quad (v_{AB})_{min} = 4$ m/s