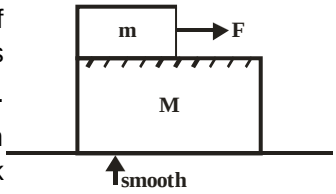
DPP No. : B12 (JEE-ADVANCED)

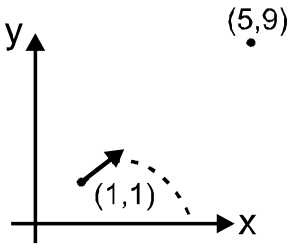
Total Marks : 42		**Max. Time : 27 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks 2 min.)**	**[06, 04]**
One or more than one options correct type ('–1' negative marking) Q.3 to Q.8	**(4 marks 2 min.)**	**[24, 12]**
Subjective Questions ('–1' negative marking) Q.9	**(4 marks 5 min.)**	**[04, 05]**
Match the Following (no negative marking) Q.10	**(8 marks 6 min.)**	**[08, 06]**

1. A plank having mass M is placed on smooth horizontal surface. Block of mass m is placed on it coefficient of friction between block and plank is $\mu_0 + kx$, where k is constant and x is relative displacement of block w.r.t. plank. A force F is applied on block where F = at, where a = 10; t is in second. Find t_0 when relative motion will occur between block and plank (use g = 10 m/s^2).



(A) $\mu_0 M + \frac{\mu_0 M^2}{m}$ (B) $\mu_0 m + \frac{\mu_0 M^2}{m}$ (C) $\mu_0 m + \frac{\mu_0 m^2}{M}$ (D) $\mu_0 M + \frac{\mu_0 m^2}{M}$

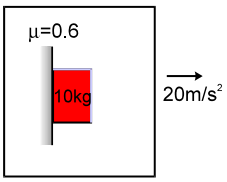
2. A particle is projected from a point (1,1) aiming towards a point (5,9). It fell on ground along x axis after 1 sec. If it falls on x–axis then the x–co–ordinate of that point is ($g = 10\ m/s^2$)



(A) 1 (B) 2

(C) 3 (D) 4

3. A car is accelerating on a horizontal road 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 as shown. The friction coefficient between the box and the wall is $\mu = 0.6$.



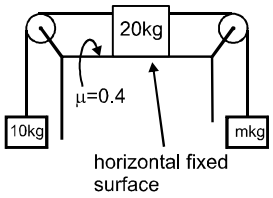
(A) The acceleration (with respect to ground) of the box will be 20 m/sec^2

(B) The friction force acting on the box will be 100 N

(C) The contact force between the vertical wall and the box will be 100 $\sqrt{5}$ N

(D) The net contact force between the vertical wall and the box is only of electromagnetic in nature.

4. Value(s) of m for which system remains at rest (pulleys and strings are ideal) [$g = 10\ m/s^2$]



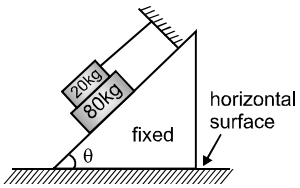
(A) 1 kg

(B) 2 kg

(C) 18 kg

(D) 20 kg

5. The system shown is in limiting equilibrium. The coefficient of friction for all contact surfaces is $\frac{1}{4}$.



(A) $\tan\theta = \frac{3}{8}$

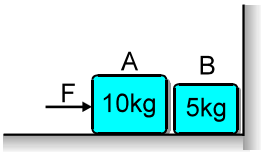
(B) Tension in the string = $\left(\frac{100}{3}g\sin\theta\right)$N

(C) Net frictional force on 80 kg block is (80 g $\sin\theta$)N

(D) Force exerted by 20 kg block on 80 kg block is (20 g $\cos\theta$)

COMPREHENSION

Two bodies A and B of masses 10 kg and 5 kg are placed very slightly separated as shown in figure. The coefficient of friction between the floor and the blocks is $\mu = 0.4$. Block A is pushed by an external force F. The value of F can be changed. When the welding between block A and ground breaks, block A will start pressing block B and when welding of B also breaks, block B will start pressing the vertical wall –



6. Choose the correct option(s)

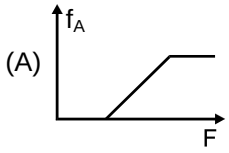
(A) If F= 20 N, the normal reaction between A and B is zero.

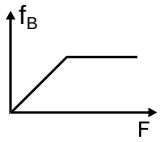
(B) If F= 45 N, the normal reaction between A and B is 5 N

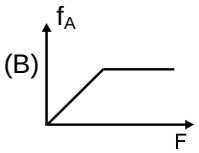
(C) If F = 65 N, the block B presses the wall

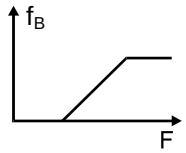
(D) If F = 70 N, the normal reaction by wall on the block B will be 10 N.

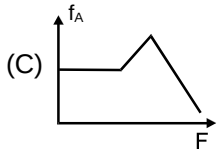
7. The force of friction acting on A and B varies with the applied force F according to curve :

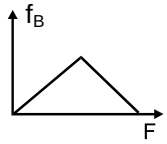
(A) 

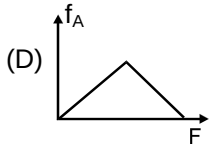


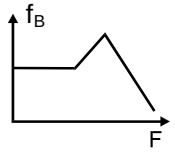
(B) 



(C) 



(D) 



8. If the vertical wall is removed and the force F is applied then choose the correct option(s)

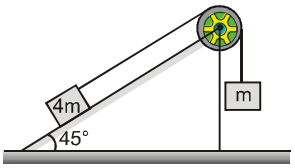
(A) If F = 90N, the normal reaction between A and B will be 50N

(B) The minimum value of F, so that A and B just start moving together is 60N

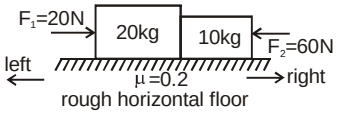
(C) If F = 120 N the accelerations of the blocks will be $4m/s^2$

(D) If F = 120 N the accelerations of the blocks will be $\frac{80}{15}$ m/s^2

9. The masses 4m and m are connected by a light string passing over a frictionless pulley fixed at inclined plane of inclinatoin 45° as shown in figure. The coefficient of friction between 4m and inclined plane is $\frac{1}{\sqrt{2}}$. When two blocks are released the frictional force on block of mass 4m has magnitude $(x\sqrt{2}-1)$ mg then the value of x is



10. Two blocks of masses 20 kg and 10 kg are kept on a rough horizontal floor. The coefficient of friction between both blocks and floor is μ = 0.2. The surface of contact of both blocks are smooth. Horizontal forces of magnitude 20 N and 60 N are applied on both the blocks as shown in figure. Match the statement in column-I with the statements in column-II.



Column-I	**Column-II**
(P) Frictional force acting on block of mass 10 kg	(1) has magnitude 20 N
(Q) Frictional force acting on block of mass 20 kg	(2) has magnitude 40 N
(R) Normal reaction exerted by 20 kg block on 10 kg block	(3) is zero
(S) Net force on system consisting of 10 kg block and 20 kg block	(4) has magnitude 60 N

(A) P-1, Q-1, R-2, S-3
(B) P-1, Q-1, R-3, S-3
(C) P-2, Q-2, R-1, S-1
(D) P-2, Q-2, R-3, S-4

DPP No. : B12 (JEE-ADVANCED)

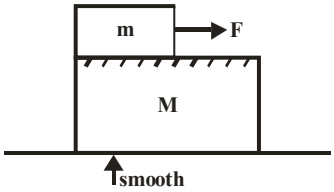
Total Marks : 42	**Max. Time : 27 min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks 2 min.) [06, 04]**
One or more than one options correct type ('–1' negative marking) Q.3 to Q.8	**(4 marks 2 min.) [24, 12]**
Subjective Questions ('–1' negative marking) Q.9	**(4 marks 5 min.) [04, 05]**
Match the Following (no negative marking) Q.10	**(8 marks 10 min.) [08, 06]**

ANSWER KEY OF DPP No. : B12

1.	(C)	2.	(C)	3.	(A,B,C,D)	4.	(B,C)	5.	(A,B,C)
6.	(A,B,C,D)	7.	(B)	8.	(B,C)	9.	2	10.	(A)

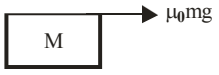
1. A plank having mass M is placed on smooth horizontal surface. Block of mass m is placed on it coefficient of friction between block and plank is $\mu_0 + kx$, where k is constant and x is relative displacement of block w.r.t. plank. A force F is applied on block where F = at, where a = 10; t is in second. Find t_0 when relative motion will occur between block and plank (use g = 10 m/s^2).

M द्रव्यमान का एक तख्ता चिकनी क्षैतीज सतह पर स्थित है। एक अन्य m द्रव्यमान का गुटका इस तख्ते पर रखा हुआ है तथा इस गुटके एवं तख्ते में मध्य घर्षण गुणांक $\mu_0 + kx$ है, यहाँ K एक नियतांक है तथा x तख्ते के सापेक्ष गुटके द्वारा चला गया विस्थापन है। एक बल F = at, जहाँ a = 10; तथा t सैकेण्ड में है, गुटके पर आरोपित किया जाता है। वह समय t_0 ज्ञात करों जब गुटके तथा तख्ते के मध्य सापेक्ष गति प्रारम्भ हो जाये (g = 10 m/s^2).



(A) $\mu_0 M + \frac{\mu_0 M^2}{m}$ (B) $\mu_0 m + \frac{\mu_0 M^2}{m}$ (C*) $\mu_0 m + \frac{\mu_0 m^2}{M}$ (D) $\mu_0 M + \frac{\mu_0 m^2}{M}$

Sol. Let at time t_0 relative motion will occur माना सापेक्ष गति प्रारम्भ होने का समय t_0 है।



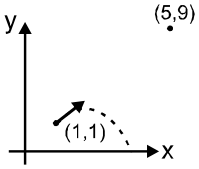
$$\mu_0 mg = Ma \quad \text{..... (1)}$$

$$10t_0 - \mu_0 mg = ma \quad \text{..... (2)}$$

From (1) and (2) ; समीकरण (1) तथा (2) से

$$t_0 = \mu_0 m + \frac{\mu_0 m^2}{M}$$

2. A particle is projected from a point (1,1) aiming towards a point (5,9). It fell on ground along x axis after 1 sec. If it falls on x–axis then the x–co–ordinate of that point is ($g = 10\ m/s^2$)
एक कण को बिन्दु (1,1) से बिन्दु (5,9) की तरफ प्रक्षेपित किया जाता है। x अक्ष के अनुदिश यह जमीन पर 1 sec में गिरता है। यदि यह x–अक्ष पर गिरता हो तो इस बिन्दु का x–निर्देशांक ज्ञात करो। ($g = 10\ m/s^2$)



(A) 1 (B) 2 (C*) 3 (D) 4

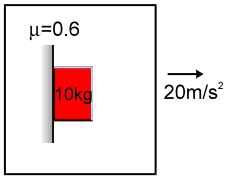
Sol. For particle कण के लिए

$1 = -u\sin\theta + \frac{1}{2}gt^2$, $\tan\theta = \frac{8}{4}$

$u = 2\sqrt{5}$ m/s

range परास $= u\cos\theta \times \text{time} = 2 \times 1 = 2$ m

3. A car is accelerating on a horizontal road 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 as shown. The friction coefficient between the box and the wall is $\mu = 0.6$.
एक कार 20 m/s^2 के त्वरण से एक क्षैतिज सड़क पर त्वरित है। कार के अन्दर एक बॉक्स m = 10 kg का ऊर्ध्वाधर दीवार के सम्पर्क में दर्शाये अनुसार रखा है। बॉक्स व दीवार के मध्य घर्षण गुणांक $\mu = 0.6$ है।

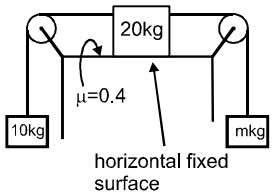


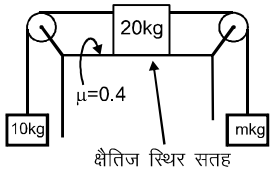
(A*) The acceleration (with respect to ground) of the box will be 20 m/sec^2
(B*) The friction force acting on the box will be 100 N
(C*) The contact force between the vertical wall and the box will be $100\sqrt{5}$ N
(D*) The net contact force between the vertical wall and the box is only of electromagnetic in nature.
(A*) बॉक्स का त्वरण जमीन के सापेक्ष 20 m/sec^2 होगा।
(B*) बॉक्स पर कार्यरत घर्षण बल 100 N होगा।
(C*) ऊर्ध्वाधर दीवार व बॉक्स के मध्य सम्पर्क बल $100\sqrt{5}$ N होगा।
(D*) ऊर्ध्वाधर दीवार व बॉक्स के मध्य कुल सम्पर्क बल केवल विद्युतचुम्बकीय प्रकृति का होगा।

Sol. The breaking force is insufficient, so the block will not slide.
भंजक बल अपर्याप्त है, इसलिये ब्लॉक नहीं फिसलेगा।

So friction force = 100 N
and acceleration (w.r.t. ground) will be 20 m/sec^2 only
Net contact force on the block = $\sqrt{(200)^2 + (100)^2} = 100\sqrt{5}$ N
All mechanical interactions are electromagnetic at microscopic level.
इसलिए घर्षण बल = 100 N
तथा त्वरण (जमीन के सापेक्ष) 20 m/sec^2 होगा।
ब्लॉक पर नेट सम्पर्क बल = $\sqrt{(200)^2 + (100)^2} = 100\sqrt{5}$ N
सूक्ष्मता स्तर पर, सभी यांत्रिक अन्तराकर्षण विद्युत चुम्बकीय होते है।

4. Value(s) of m for which system remains at rest (pulleys and strings are ideal) [g = 10 m/s^2] :
m के किस मान के लिए निकाय विरामावस्था में रहता है (घिरनी व डोरी आदर्श है) [g = 10 m/s^2] :





(A) 1 kg (B*) 2 kg (C*) 18 kg (D) 20 kg

Sol. $f_{max} = 20 \times 0.4 \times 10 = 80$ N

For equilibrium साम्यावस्था के लिए

minimum value of m (m का न्यूनतम मान) $\Rightarrow$ m(10) = 100 – 80 $\Rightarrow$ m = 2 kg

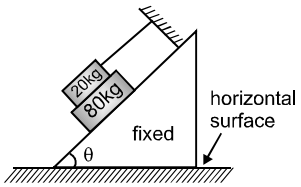
maximum value of m (m का अधिकतम मान) $\Rightarrow$ m(10) = 100 + 80 $\Rightarrow$ m = 18 kg

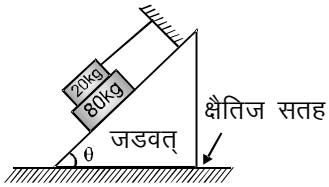
So, (B) and (C) are correct.

अतः, (B) तथा (C) सही है।

5. The system shown is in limiting equilibrium. The coefficient of friction for all contact surfaces is $\frac{1}{4}$.

प्रदर्शित निकाय सीमान्त साम्यावस्था में है। सभी सम्पर्क सतहों के लिए घर्षण गुणांक $\frac{1}{4}$ है –





(A*) $\tan\theta = \frac{3}{8}$

(B*) Tension in the string डोरी में तनाव = $\left(\frac{100}{3} g\sin\theta\right)$N

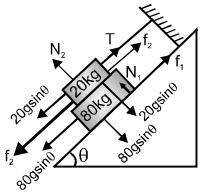
(C*) Net frictional force on 80 kg block is (80 g sinθ)N

80 kg के गुटके पर परिणामी घर्षण बल (80 g sinθ)N है।

(D) Force exerted by 20 kg block on 80 kg block is (20 g cosθ)

20 kg के गुटके द्वारा 80 kg के गुटके पर आरोपित बल (20 g cosθ) है।

Sol.



$20g \sin\theta + f_2 = T$

$20g \sin\theta + \mu(20g \cos\theta) = T$

$80g \sin\theta + \mu(100g \cos\theta) + m(20g \cos\theta)$

$\tan\theta = \frac{3}{8}$

$T = 20g \sin\theta + \mu\, 20g \cos\theta$

$= 20g \sin\theta + \frac{1}{4} \times 20 \times g \times \frac{8}{3} \sin\theta = \left(\frac{100}{3} g\sin\theta\right)$ N

Net friction on 80 kg पर परिणामी घर्षण = $f_1 + f_2 = 80\, g\sin\theta$

force on 80 kg due to 20 kg is $\sqrt{(20g\cos\theta)^2 + (\mu 20g\sin\theta)^2}$.

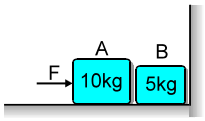
20 kg के कारण 80 kg पर बल है $\sqrt{(20g\cos\theta)^2 + (\mu 20g\sin\theta)^2}$.

COMPREHENSION

Two bodies A and B of masses 10 kg and 5 kg are placed very slightly separated as shown in figure. The coefficient of friction between the floor and the blocks is $\mu = 0.4$. Block A is pushed by an external force F. The value of F can be changed. When the welding between block A and ground breaks, block A will start pressing block B and when welding of B also breaks, block B will start pressing the vertical wall –

अनुच्छेद

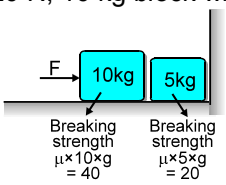
दो पिण्ड A व B जिनके द्रव्यमान 10 kg व 5 kg है बहुत ही कम दूरी पर रखे गये है जैसा चित्र में प्रदर्शित है। पिण्डो और तल के बीच घर्षण गुणांक $\mu = 0.4$ है। पिण्ड A को बाह्य बल F से धकेला जाता है। F का मान परिवर्तनशील है। जब पिण्ड A और जमीन के बीच वेल्डिंग टूट जाती है। तब पिण्ड A, पिण्ड B को दबाना प्रारम्भ करता है। जब पिण्ड B की वेल्डिंग टूट जाती है तो पिण्ड B ऊर्ध्वाधर दीवार को दबाना प्रारम्भ करता है।



6. Choose the correct option(s)
सही विकल्प/विकल्पों का चयन कीजिये।

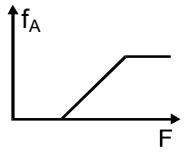
(A*) If F= 20 N, the normal reaction between A and B is zero.
(B*) If F= 45 N, the normal reaction between A and B is 5 N
(C*) If F = 65 N, the block B presses the wall
(D*) If F = 70 N, the normal reaction by wall on the block B will be 10 N.
(A*) यदि F= 20 N है, A व B के मध्य अभिलम्ब बल शून्य है।
(B*) यदि F= 45 N है, A व B के मध्य अभिलम्ब बल 5 N है।
(C*) यदि F = 65 N है, ब्लॉक B दीवार को दबाता है।
(D*) यदि F = 70 N है, ब्लॉक B पर दीवार द्वारा आरोपित अभिलम्ब प्रतिक्रिया 10 N होगी।

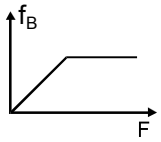
Sol. (A)If F = 20 N, 10 kg block will not move and it would not press 5 kg block So N = 0.

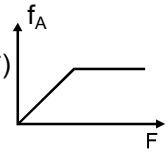


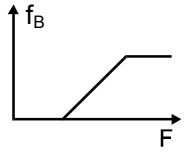
(B) since 60 N > F > 40 N, so A will press B
(C) since F > 60 N, so B will press the wall
(d) since F > 60 N, so the net force exerted by B on the wall = 10 N.
Normal reaction by wall on B will be 10 N

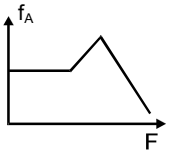
7. The force of friction acting on A and B varies with the applied force F according to curve :
A और B पर लगने वाला घर्षण बल, आरोपित बल F के साथ किस वक्र के अनुसार बदलता है :

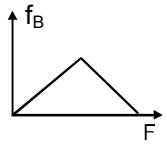
(A)


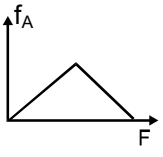


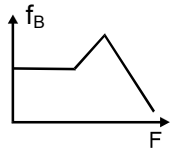
(B*)




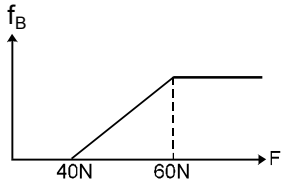
(C)




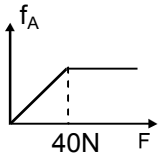
(D)




Sol.



Until the 10 kg block is sticked with ground (... F = 40 N),
No force will be flet by 5 kg block. After F = 40 N, the friction force on 5 kg increases, till F = 60 N,
and after that, the kinetic friction start acting on 5 kg block, which will be constant (20N)



till $F \leq 40N$, $f_A = F$ (static friction)

For $F > 40$ N, $f_A = 40$ N (Kinetic friction)

जब तक 10 kg का ब्लॉक सतह के साथ चिपका रहता है (... F = 40 N), तो 5 kg का ब्लॉक कोई बल महसूस नही करेगा। F = 40 N, के बाद 5 kg वाले ब्लॉक पर घर्षण बल F = 60 N, तक बढ़ेगा इसके पश्चात 5 kg के ब्लॉक पर नीयत गतिक घर्षण बल कार्य करेगा जिसका मान (20N) है।

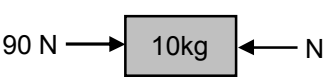
8. If the vertical wall is removed and the force F is applied then choose the correct option(s)
यदि ऊर्ध्वाधर दीवार को हटा दिया जाता है तथा बल F आरोपित किया जाता है तब सही विकल्प/विकल्पों का चयन कीजिये।

(A) If F = 90N, the normal reaction between A and B will be 50N
(B*) The minimum value of F, so that A and B just start moving together is 60N
(C*) If F = 120 N the accelerations of the blocks will be $4m/s^2$
(D) If F = 120 N the accelerations of the blocks will be $\frac{80}{15}$ m/s^2

(A*) यदि F = 90N है, A व B के मध्य अभिलम्ब बल 50N होगा।
(B*) F का न्यूनतम मान 60N है ताकि A व B साथ–साथ ठीक गति प्रारम्भ करें।
(C*) यदि F = 120 N है, ब्लॉकों का त्वरण $4m/s^2$ होगा।
(D) यदि F = 120 N है, ब्लॉकों का त्वरण $\frac{80}{15}$ m/s^2 होगा।

Sol. System = A + B

$a_{sys} = \frac{90-60}{15} = 2\ m/s^2$

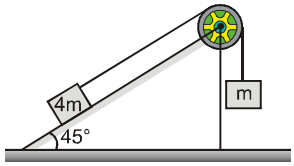


$90 - N = 10 \times 2$
$N = 70$ N
If F = 120N

$a_{sys} = \frac{120-60}{15} = 4m/s^2$

9. The masses 4m and m are connected by a light string passing over a frictionless pulley fixed at inclined plane of inclinatoin 45° as shown in figure. The coefficient of friction between 4m and inclined plane is $\frac{1}{\sqrt{2}}$. When two blocks are released the frictional force on block of mass 4m has magnitude $(x\sqrt{2}-1)$ mg then the value of x is

4m तथा m द्रव्यमान 45° के कोण पर झुके नत तल पर स्थिर (fixed) घर्षणरहित घिरनी के ऊपर से गुजर रही हल्की डोरी द्वारा चित्रानुसार जुड़े है। 4m तथा नत तल के मध्य घर्षण गुणांक $\frac{1}{\sqrt{2}}$ है। जब दोंनो ब्लॉको को छोड़ा जाता है। 4m द्रव्यमान के ब्लॉक पर घर्षण बल का परिमाण $(x\sqrt{2}-1)$ mg है। x का मान होगा



Ans. 2

Sol. Maximum value of friction force between 4m and inclined plane

4m तथा नत तल के मध्य घर्षण बल का अधिकतम मान

$$= \mu (4mg) \cos 45°$$

$$= \frac{1}{\sqrt{2}} (4mg) \frac{1}{\sqrt{2}} = 2mg$$

Here pulling force तयहाँ खींचाव बल

$$F_P = 4mg \cos 45 - mg = (2\sqrt{2}-1)\ mg < 2\ mg$$

$\therefore$ Block will not move. ब्लॉक गति नहीं करेगा

$\therefore$ Acceleration of 4m block

4m ब्लॉक का त्वरण

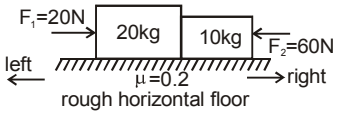
= 0 , T = mg

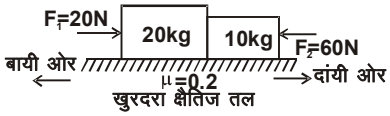
$\therefore$ frictional force on 4m block

4m द्रव्यमान पर घर्षण बल $= (2\sqrt{2}-1)$ mg

10. Two blocks of masses 20 kg and 10 kg are kept on a rough horizontal floor. The coefficient of friction between both blocks and floor is μ = 0.2. The surface of contact of both blocks are smooth. Horizontal forces of magnitude 20 N and 60 N are applied on both the blocks as shown in figure. Match the statement in column-I with the statements in column-II.

20 kg व 10 kg द्रव्यमान के दो ब्लॉक खुरदरे क्षैतिज धरातल पर रखे हुये है। धरातल एवं दोनों ब्लाक के मध्य घर्षण गुणांक μ = 0.2 है। दोनों ब्लॉक की उभयनिष्ठ सम्पर्क सतह चिकनी है। 20 N तथा 60 N के दो क्षैतिज बल चित्रानुसार दोनो ब्लॉक पर आरोपित किये जाते है तो स्तम्भ-I के कथनों को स्तम्भ-II के कथनों से मिलान करावे।





Column-I	Column-II
(P) Frictional force acting on block of mass 10 kg	(1) has magnitude 20 N
(Q) Frictional force acting on block of mass 20 kg	(2) has magnitude 40 N
(R) Normal reaction exerted by 20 kg block on 10 kg block	(3) is zero
(S) Net force on system consisting of 10 kg block and 20 kg block	(4) has magnitude 60 N

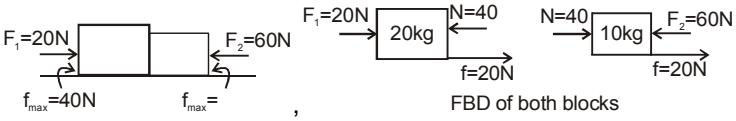
स्तम्भ-I	स्तम्भ-II
(P) 10 kg द्रव्यमान के ब्लॉक पर घर्षण बल	(1) 20 N परिमाण
(Q) 20 kg द्रव्यमान के ब्लॉक पर घर्षण बल	(2) 40 N परिमाण
(R) 20 kg द्रव्यमान के ब्लॉक द्वारा 10 kg द्रव्यमान के ब्लॉक पर आरोपित अभिलम्ब प्रतिक्रिया बल	(3) शून्य
(S) 10 kg द्रव्यमान व 20 kg द्रव्यमान के ब्लॉक निकाय पर कुल बल	(4) 60 N परिमाण

(A*) P-1, Q-1, R-2, S-3
(B) P-1, Q-1, R-3, S-3
(C) P-2, Q-2, R-1, S-1
(D) P-2, Q-2, R-3, S-4

Sol. The minimum horizontal force required to push the two block system towards left
दोनों ब्लॉक निकाय को बांयी ओर धक्का देने के लिए आवश्यक न्यूनतम क्षैतिज बल

$$= 0.2 \times 20 \times 10 + 0.2 \times 10 \times 10 = 60.$$

Hence the two block system is at rest. The FBD of both of blocks is as shown. The friction force f and normal reaction N for each block is as shown.
अतः दोनों ब्लॉक निकाय विरामावस्था में है। दोनों ब्लॉकों का FBD चित्रानुसार है। प्रत्येक ब्लॉक के लिए घर्षण बल f तथा अभिलम्ब प्रतिक्रिया N चित्रानुसार है।



,
FBD of both blocks

Hence magnitude of friction force on both blocks is 20 N and is directed to right for both blocks. Normal reaction exerted by 20 kg block on 10 kg block has magnitude 40 N and is directed towards right. Net force on system of both blocks is zero.
अतः दोनों ब्लॉक पर घर्षण बल का परिमाण 20 N है। तथा दिशा दांयी ओर है दोनों ब्लॉक के लिए दांयी ओर होगा 10 kg के ब्लॉक पर 20 kg द्वारा लगाया गया अभिलम्ब बल 40 N परिमाण के बराबर है। तथा दिशा दांयी ओर है दोनों ब्लॉक निकाय पर कुल बल शून्य है।