PRAYAS

JEE 2025

Lecture - 13

Physics

Laws Of Motion

By- Saleem Ahmed Sir

Topics *to be covered*

1. Friction Questions Practice

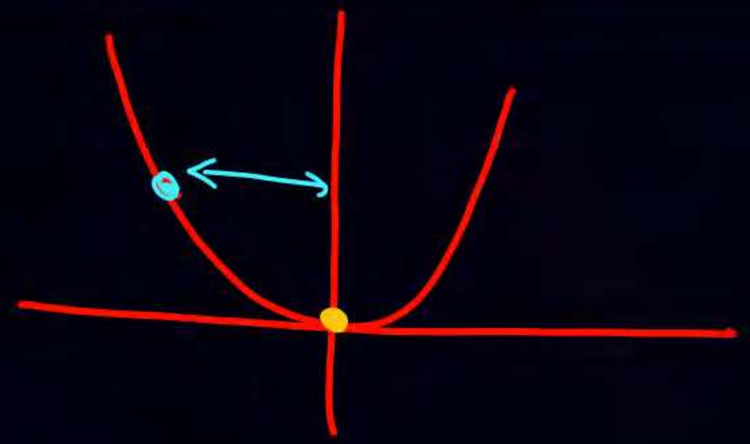
2. Spring Cutting
3. Two block System
4.

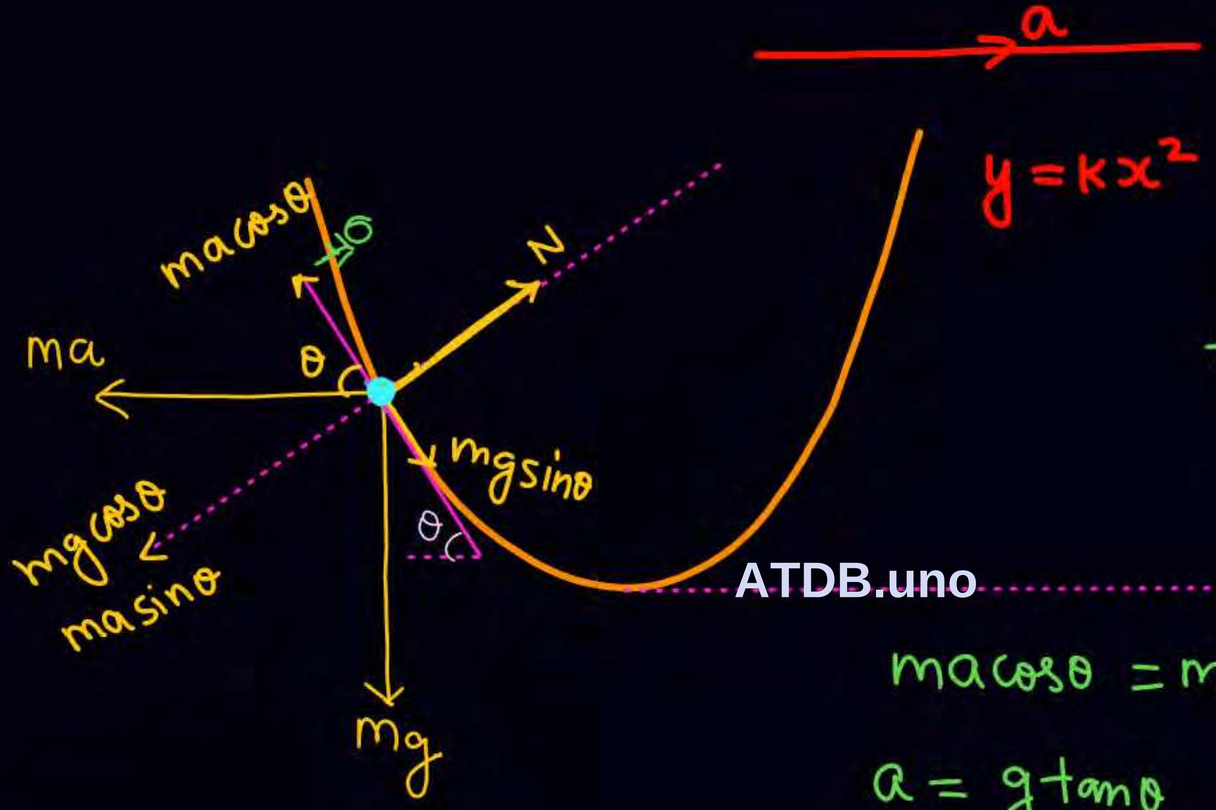
it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is **[IIT-JEE-2009]**

एक तार के टुकड़े को, एक परवलय $y = kx^2$ (ऊर्ध्वाधर y अक्ष) की आकृति में मोड़ा गया है जिसमें m द्रव्यमान का एक मोती है। मोती, तार पर बिना घर्षण के फिसल सकता है। जब तार विरामावस्था में होता है तब मोती, परवलय के निम्नतम बिन्दु पर होता है। अब तार को x अक्ष के समान्तर नियत त्वरण a से त्वरित किया जाता है। y अक्ष से मोती की नयी साम्यावस्था की स्थिति की दूरी, जहां मोती तार के सापेक्ष विरामावस्था में रूक सकता है, होगी:-

(A) $\frac{a}{gk}$ (B) $\frac{a}{2gk}$ (C) $\frac{2a}{gk}$ (D) $\frac{a}{4gk}$

Ans. (B)



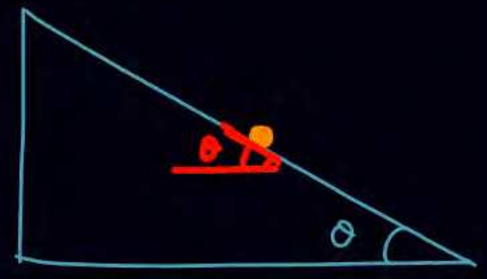


$\tan\theta = \text{slope} = \frac{dy}{dx} = 2kx$

$ma\cos\theta = mg\sin\theta$

$a = g\tan\theta$

$a = g \cdot 2kx \qquad x = \frac{a}{2kg}$



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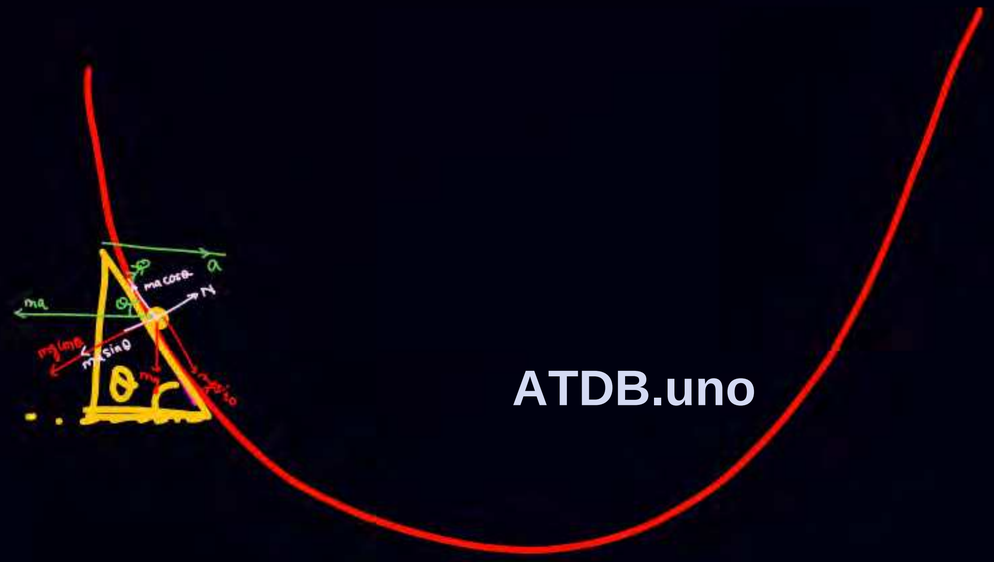

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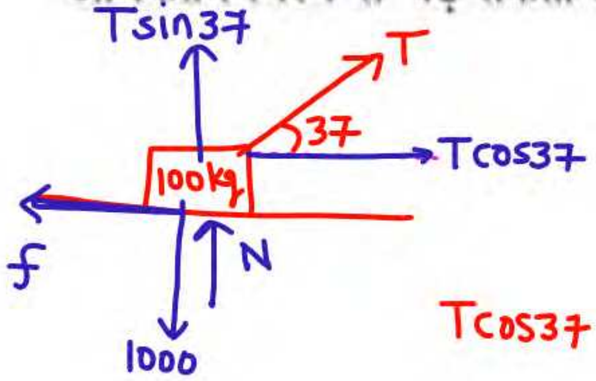
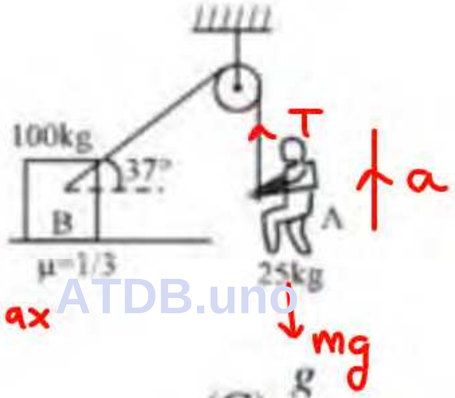
Block B of mass 100 kg rests on a rough surface of friction coefficient $\mu = 1/3$. A rope is tied to block B as shown in figure. The maximum acceleration with which boy A of 25 kg can climbs on rope without making block move is :

एक 100 kg द्रव्यमान वाला ब्लॉक B घर्षण गुणांक $\mu = 1/3$ वाली खुरदरी सतह पर विरामावस्था में रखा है। ब्लॉक B से चित्रानुसार एक रस्सी को बांधा गया है। एक 25 kg द्रव्यमान का लड़का A, बिना ब्लॉक को गति कराये रस्सी पर कितने अधिकतम त्वरण से चढ़ सकता है?





$T\cos 37 \le (f_s)_{max}$

$T - 250 = 25a \Rightarrow \frac{1000}{3} - 250 = 25a$

$a = \frac{250}{3 \times 25} = \frac{10}{3}$

(A) $\frac{4g}{3}$ (B) $\frac{g}{3}$ (C) $\frac{g}{2}$ (D) $\frac{3g}{4}$

Ans. (B)

$T\cos 37 = \mu(1000 - T\sin 37)$

$\frac{4T}{5} = \frac{1}{3}\left(1000 - \frac{3T}{5}\right)$

$\frac{4T}{5} = \frac{1000}{3} - \frac{T}{5}$

Put

$T = \frac{1000}{3}$

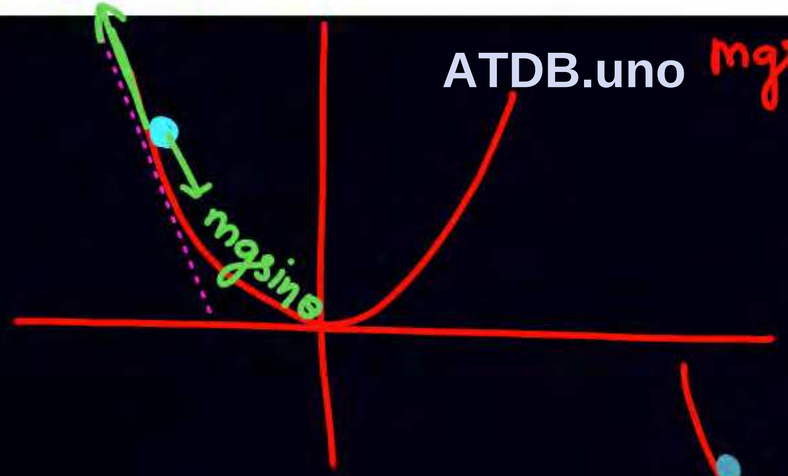
14. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is _____ cm. **[JEE-Main-2021_Feb]**

$\frac{1}{4}m = 25\,cm$

एक आनत तल इस प्रकार झुका है कि उसकी ऊर्ध्वाधर अनुप्रस्थकाट $y = \frac{x^2}{4}$ द्वारा निरूपित की गयी है, यहाँ y ऊर्ध्वाधर तथा x क्षैतिज दिशा में हैं। यदि इस वक्रित तल का ऊपरी पृष्ठ रूक्ष है और इसका घर्षण गुणांक $\mu = 0.5$ है, तो वह अधिकतम ऊँचाई जिसमें कोई स्थिर गुटका नीचे की ओर नहीं फिसलेगा, _____ cm होगी। **[JEE-Main-2021_Feb]**

Ans. (25)

$(f_s)_{max}$



$mg\sin\theta = (f_s)_{max} = \mu_s mg\cos\theta$

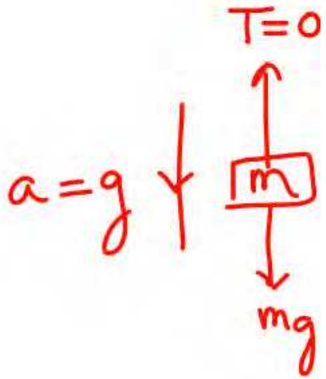
$\tan\theta = \mu$

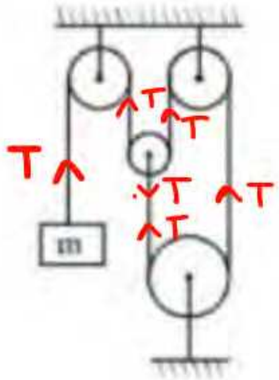
$\frac{dy}{dx} = \frac{2x}{4} = \frac{1}{2}$

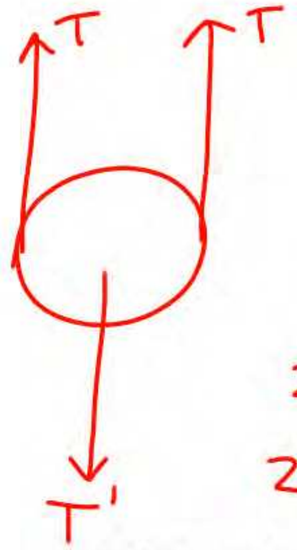
$x = 1$

$y = \frac{1}{4}$

यदि रस्सी तथा सभी घिरनियां आदर्श हैं तो द्रव्यमान m का त्वरण होगा :-







$2T = T' = T$

$2T = T$

$2T - T = 0$

$T = 0$

(A) $\frac{g}{2}$ (B) 0 (C) g (D) dependent on m

Ans. (C)

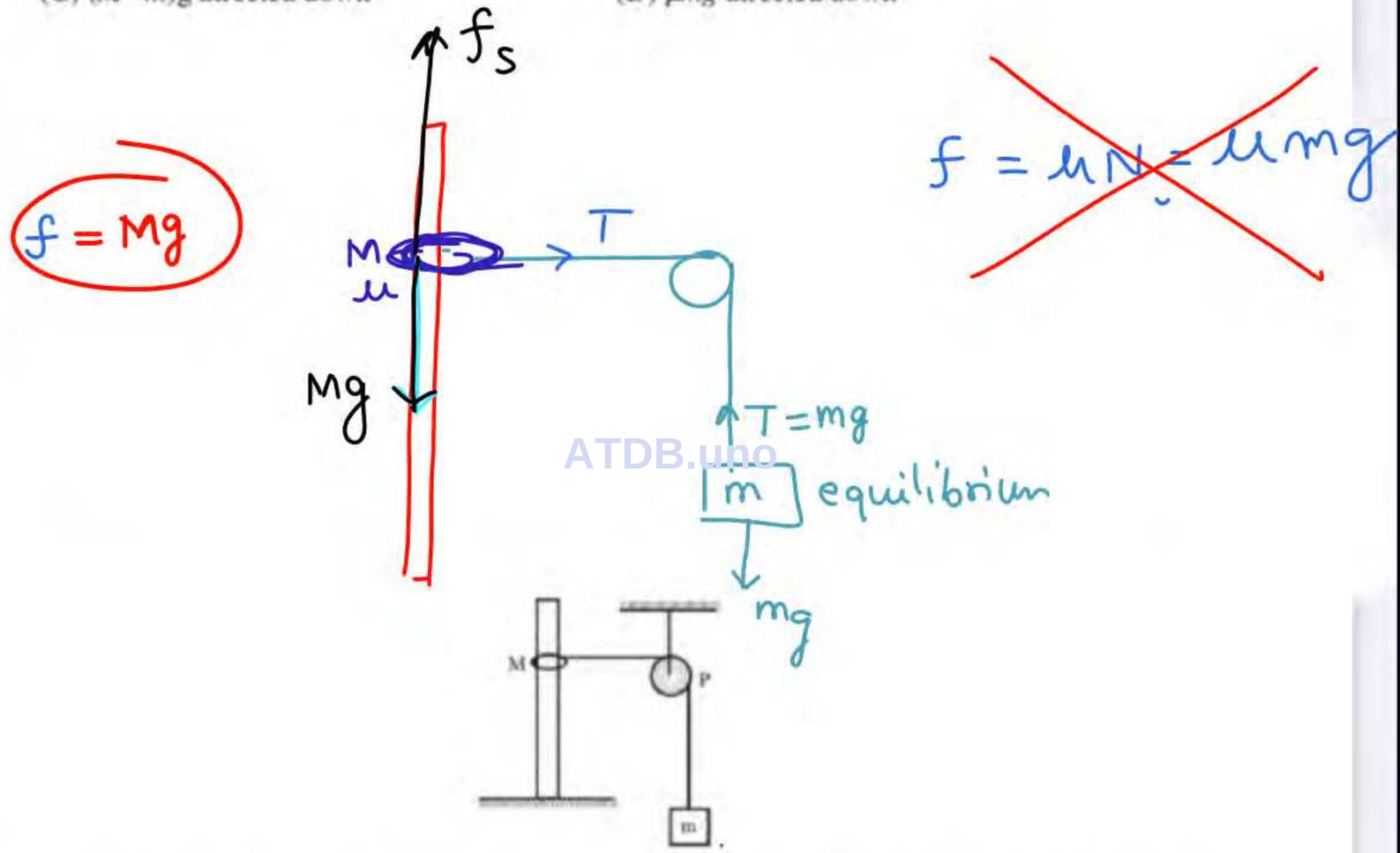
pulley P does not offer any friction and coefficient of friction between pole and M is μ. The frictional force offered by the pole on M is

(A) Mg directed up

(B) μmg directed up

(C) $(M - m)g$ directed down

(D) μmg directed down



दर्शाये गये चित्र में M द्रव्यमान की वलय तथा m द्रव्यमान का ब्लॉक साम्यावस्था में है। डोरी हल्की है तथा घिरनी P कोई घर्षण उत्पन्न नहीं करती और M तथा खम्भे के मध्य घर्षण गुणांक का मान μ है। खम्भे द्वारा M पर आरोपित घर्षण बल है–

(A) Mg ऊपर की ओर

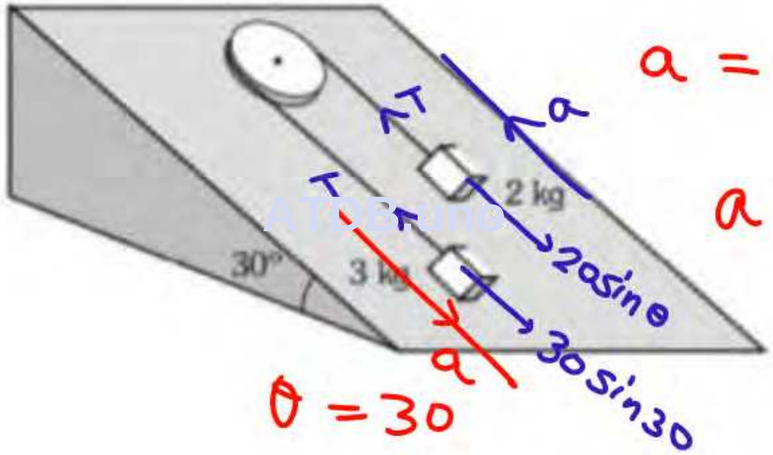
(B) μ mg ऊपर की ओर

(C) $(M - m)$ g नीचे की ओर

(D) μ mg नीचे की ओर

Two blocks of masses 2.0 kg and 3.0 kg are connected by light inextensible string. The string passes over an ideal pulley pivoted to a fixed axel on a smooth incline plane as shown in the figure. When the blocks are released, find magnitude of their accelerations.

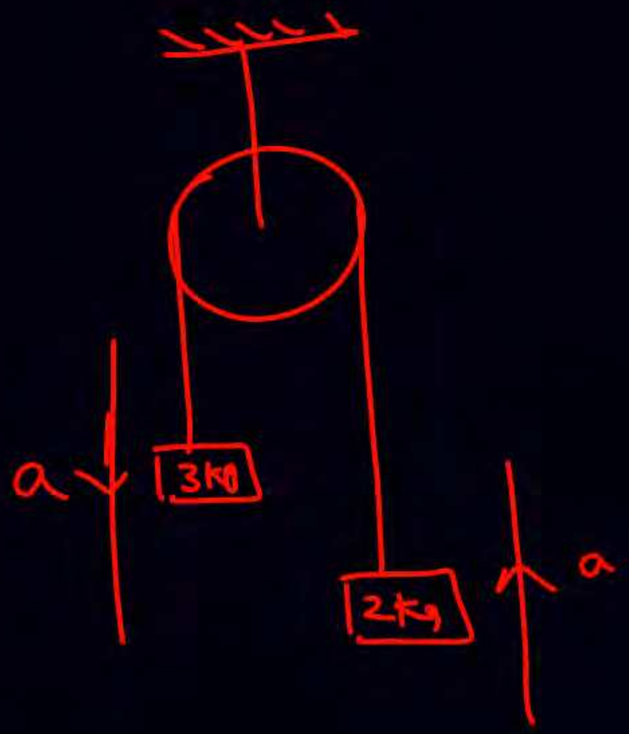
दो ब्लॉक जिनका द्रव्यमान 2 kg और 3 kg है एक हल्की अवितान्य रस्सी द्वारा जुड़े हैं। रस्सी एक आदर्श घिरनी से गुजरती है, जो चित्रानुसार एक चिकने नत-तल पर स्थिर एक्सेल पर कीलकित है। जब ब्लॉक को छोड़ा जाता है, तो उनका त्वरण ज्ञात कीजिये।



$$a = \frac{3g\sin\theta - 2g\sin\theta}{3+2}$$

$$a = \frac{g\sin\theta}{5} = g/10$$

Ans. $\frac{g}{10} m/s^2$



$$a = \frac{3g - 2g}{3 + 2} = \frac{g}{5}$$

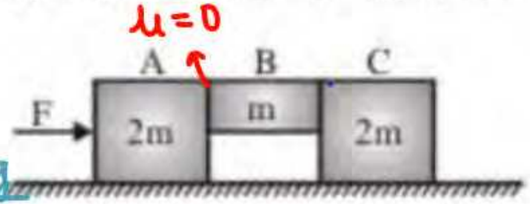
The system is pushed by a force F as shown in figure. All surfaces are smooth except between B and C. Friction coefficient between B and C is μ. Minimum value of F to prevent block B from downward slipping is :-

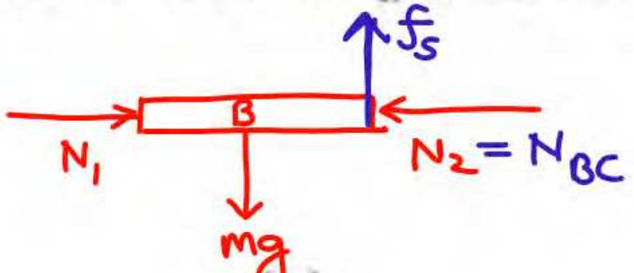
$mg \le (f_s)_{max} \Rightarrow mg \le \mu \frac{2F}{5} \Rightarrow \frac{5mg}{2\mu} \le F$

चित्र में प्रदर्शित निकाय को F बल द्वारा धकेला जाता है। B एवं C के मध्य की सतह को छोड़कर सभी सतहें चिकनी हैं। B एवं C के मध्य घर्षण गुणांक μ है। ब्लॉक B को नीचे की ओर गिरने से रोकने के लिये F का न्यूनतम मान होगा:

$mg = (f_s)_{max} = \mu N_{BC}$

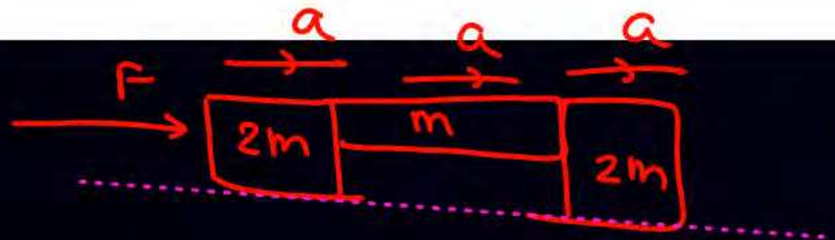
$mg = \mu \frac{2F}{5}, \quad F = \frac{5mg}{2\mu}$



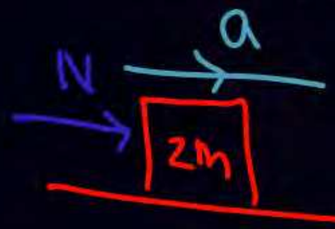


(A) $\left(\frac{3}{2\mu}\right)mg$ (B) $\left(\frac{5}{2\mu}\right)mg$ (C) $\left(\frac{5}{2}\right)\mu mg$ (D) $\left(\frac{3}{2}\right)\mu mg$

Ans. (B)



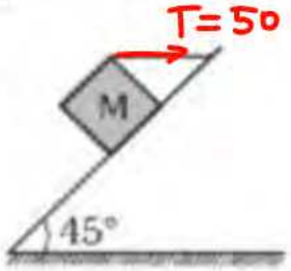
$a = \frac{F}{5m}$

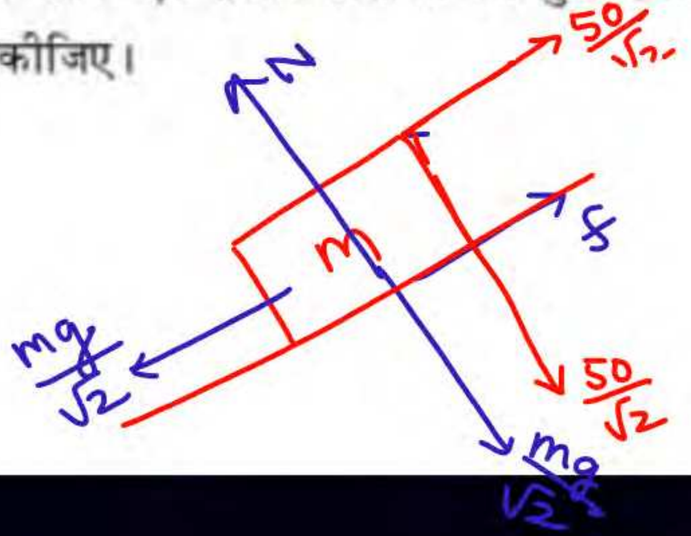


$N = 2m \times a = 2m \times \frac{F}{5m} = \frac{2F}{5}$

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. Calculate the minimum coefficient of friction between the block and inclined plane.

15kg द्रव्यमान का एक ब्लॉक खुरदरे नत तल पर चित्रानुसार विराम में है। ब्लॉक एक क्षैतिज रस्सी से बँधा हुआ है जिसमें तनाव 50N है। ब्लॉक तथा नत तल के मध्य न्यूनतम घर्षण गुणांक ज्ञात कीजिए।





$$f + \frac{50}{\sqrt{2}} = \frac{150}{\sqrt{2}}$$

$$\mu_s N = \frac{150}{\sqrt{2}} - \frac{50}{\sqrt{2}}$$

$$\mu_s \times \left(\frac{150}{\sqrt{2}} + \frac{50}{\sqrt{2}}\right) = \frac{100}{\sqrt{2}}$$

Ans. 0.5

$$\mu_s = \frac{1}{2}$$

Block M slides down on frictionless incline as shown. Find the minimum friction coefficient so that m does not slide with respect to M.

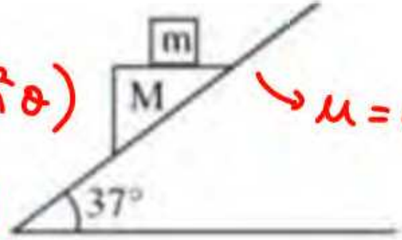
चित्रानुसार ब्लॉक M एक घर्षणरहित नत तल पर नीचे की ओर फिसलता है। वह न्यूनतम घर्षण गुणांक ज्ञात कीजिये, ताकि m, M के सापेक्ष इस पर गति ना करे?

m

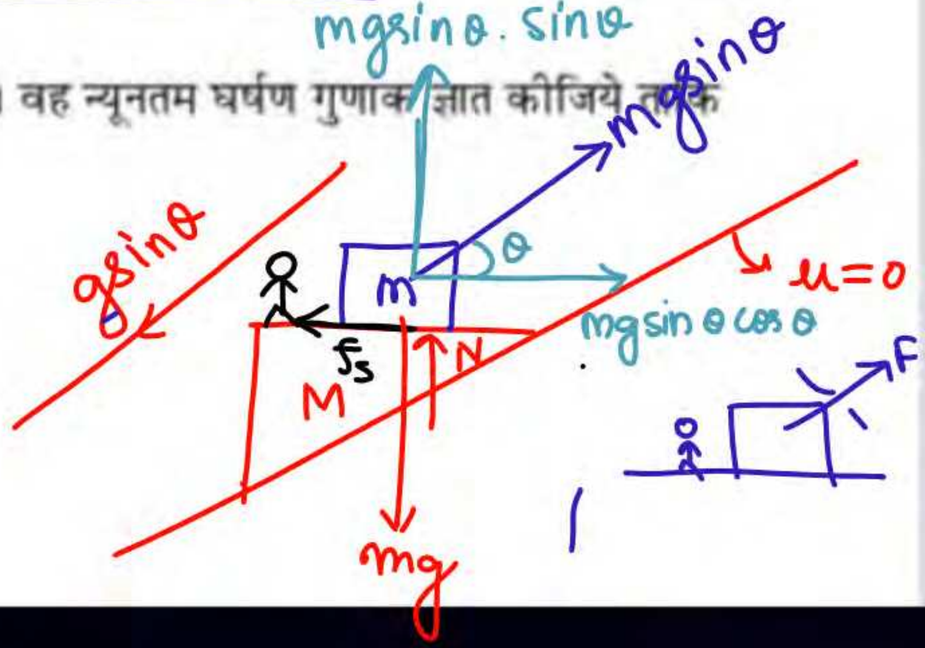
$mg\sin\theta\cos\theta \le (f_s)_{max}$

$mg\sin\theta\cos\theta \le \mu(mg - mg\sin^2\theta)$

$\sin 37\cos 37 \le \mu(1-\sin^2 37)$



Ans. 3/4 $\quad \frac{3}{5}\times\frac{4}{5} \le \mu\times\left(\frac{4}{5}\right)^2$



$\mu \le 3/4$

$\mu \le \frac{3}{4}$

of 100 N. If both man & plank move together, find force of friction acting on man.

T=100N

(A) $\frac{100}{3}$ N towards left

(B) $\frac{100}{3}$ N towards right

(C) $\frac{250}{3}$ N towards left

(D) $\frac{250}{3}$ N towards right

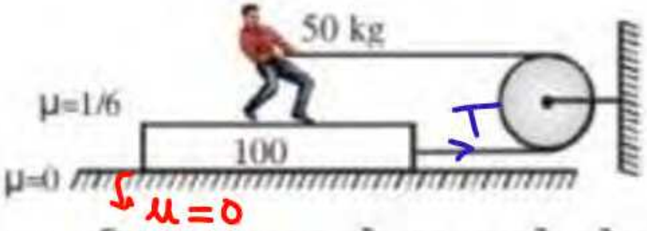
$T - f = 50a$

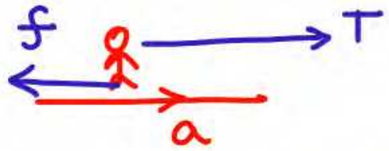
$T + f = 100a$

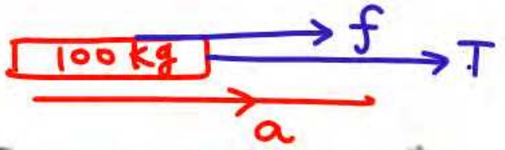
$2T = 150a$

$200 = 150a$

$a = \frac{4}{3}$







द्रव्यमान 50 किग्रा का एक व्यक्ति 100 किग्रा द्रव्यमान के एक तख्ते को जो चिकनी क्षैतिज सतह पर रखा हुआ है, चित्रानुसार 100N के बल से खींच रहा है। यदि व्यक्ति एवं तख्ता दोनों साथ-साथ गति करते हों तो व्यक्ति पर कार्यरत घर्षण बल ज्ञात कीजिए।

(A) $\frac{100}{3}$ N बांयी तरफ

(B) $\frac{100}{3}$ Nदांयी तरफ

(C) $\frac{250}{3}$ N बांयी तरफ

(D) $\frac{250}{3}$ N दांयी तरफ

$100 - f = 50 \times \frac{4}{3}$

$f = 100 - \frac{200}{3} = \frac{100}{3}$

Ans. (A)

A thin rod of length 1 m is fixed in a vertical position inside a train, which is moving horizontally with constant acceleration 4 m/s^2. A bead can slide on the rod, and friction coefficient between them is 1/2. If the bead is released from rest at the top of the rod, find the time when it will reach at the bottom.[g = 10 m/s^2]

1m लम्बाई की एक पतली छड़ एक ट्रेन के अन्दर उर्ध्वाधर स्थिति में स्थिर है जो कि 4 m/s^2 के नियत त्वरण से क्षैतिज दिशा में गति कर रही है। एक मोती (bead) छड़ पर फिसल सकता है तथा उनके मध्य घर्षण गुणांक 0.5 है। यदि मोती को छड़ के शीर्ष से विराम अवस्था से छोड़ा जाता है तो वह समय ज्ञात कीजिये जब यह पेंदे पर पहुँचेगा (g=10 m/s^2)

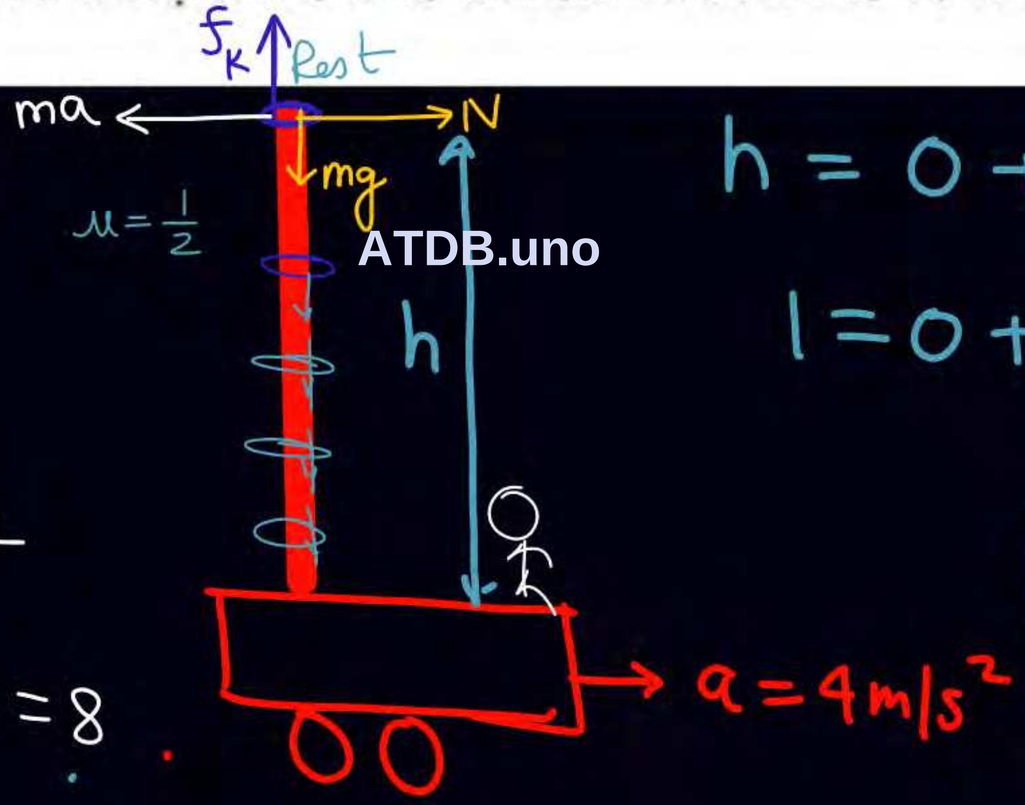
Ans. 1/2 s

$$a = \frac{mg - f_K}{m}$$

$$= \frac{mg - \mu N}{m}$$

$$= \frac{mg - \mu ma}{m}$$

$$a = 10 - \frac{1}{2} \times 4 = 8$$



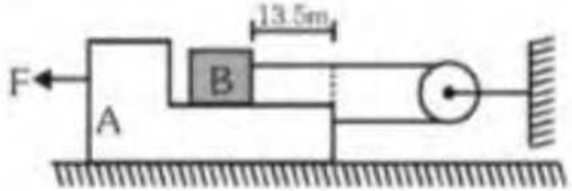
$$h = 0 + \frac{1}{2} a_y t^2$$

$$1 = 0 + \frac{1}{2} \times 8 \times t^2$$

$$t = \frac{1}{2} \text{ sec}$$

A 1 kg block 'B' rests as shown on a frictionless bracket 'A' of same mass. Constant force F = 3N starts to act at time t = 0, when the distance of block B from the end of bracket is 13.5m. Find time (in sec), when block B falls off the bracket.

1 kg द्रव्यमान का एक ब्लॉक B चित्रानुसार समान द्रव्यमान के एक घर्षण रहित ब्रेकेट A पर स्थित है। जब ब्लॉक B की ब्रेकेट के सिरे से दूरी 13.5m है तो समय t = 0 पर एक नियत बल F = 3N लगना प्रारम्भ होता है। वह समय (सेकण्ड में) ज्ञात कीजिये जब ब्लॉक B, A से गिर जायेगा।



Ans. 3

A block of mass $m_1 = 1$ kg another mass $m_2 = 2$kg, are placed together (see figure) on an inclined plane with angle of inclination θ. Various values of θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In List II expressions for the friction on block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g.

[**useful information :** $\tan(5.5°) \approx 0.1$; $\tan(11.5°) \approx 0.2$; $\tan(16.5°) \approx 0.3$]

एक आनत तल पर, जिसका आनत कोण θ है, द्रव्यमान $m_1 = 1$ kg तथा द्रव्यमान $m_2 = 2$kg के दो खण्ड आपस में सटाकर रखे गए हैं (जैसा चित्र में दिखाया गया है)। कोण θ के विभिन्न मान सूची-I में दिए गए हैं। खण्ड m_1 तथा आनत तल के बीच घर्षण गुणांक सदैव शून्य है। खण्ड m_2 तथा आनत तल के बीच स्थैतिक तथा गतिज घर्षण गुणांक $\mu = 0.3$ समान है। सूची-II में खण्ड m_2 पर लगने वाले घर्षण बल के व्यंजक दिए हैं। सूची-I को सूची-II से सुमेलित कीजिए तथा सूचियों के नीचे दिए गए कोड का प्रयोग करके सही उत्तर चुनिए। गुरुत्वीय त्वरण g से अंकित है।

[**आवश्यक आँकड़े :** $\tan(5.5°) \approx 0.1$; $\tan(11.5°) \approx 0.2$; $\tan(16.5°) \approx 0.3$] **[IIT-JEE-2014]**

List–I/सूची–I

(P) $\theta = 5°$

(Q) $\theta = 10°$

(R) $\theta = 15°$

(S) $\theta = 20°$

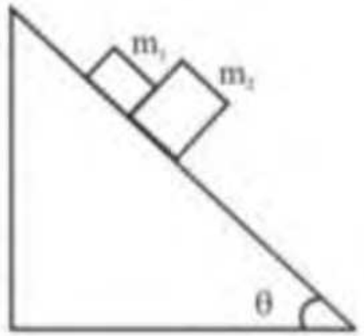
List–II/सूची–II

(1) $m_2 g \sin\theta$

(2) $(m_1 + m_2) g \sin\theta$

(3) $\mu m_2 g \cos\theta$

(4) $\mu(m_1 + m_2) g \cos\theta$



Code/कूट: :

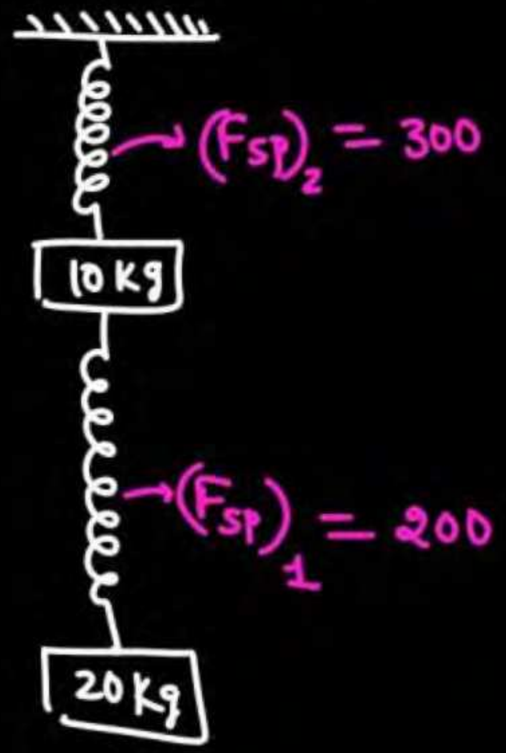
(A) P-1, Q-1, R-1, S-3

(B) P-2. Q-2, R-2, S-3

(C) P-2,. Q-2, R-2, S-4

(D) P-2, Q-2, R-3, S-3

spring cutting

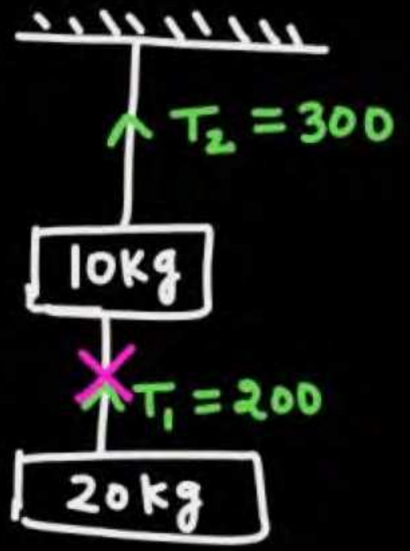


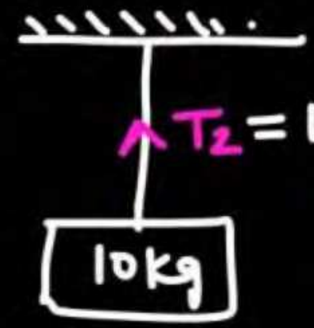
If at $t=0$
Lower spring is cut

Spring → Lazy, सुस्त
आलसी

→ Sudden change नहीं होता

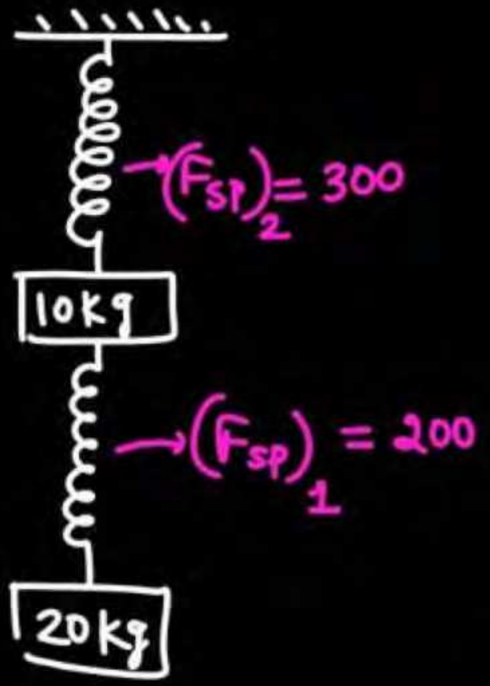
$t=0$



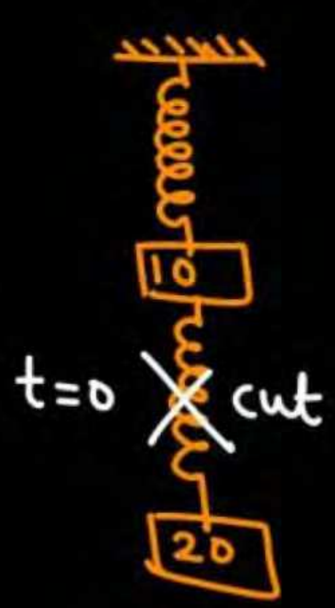


Lower String is cut

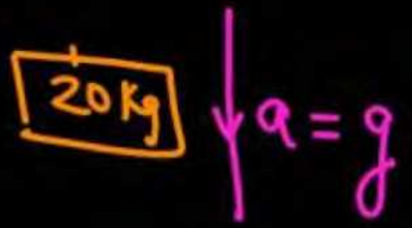
Q

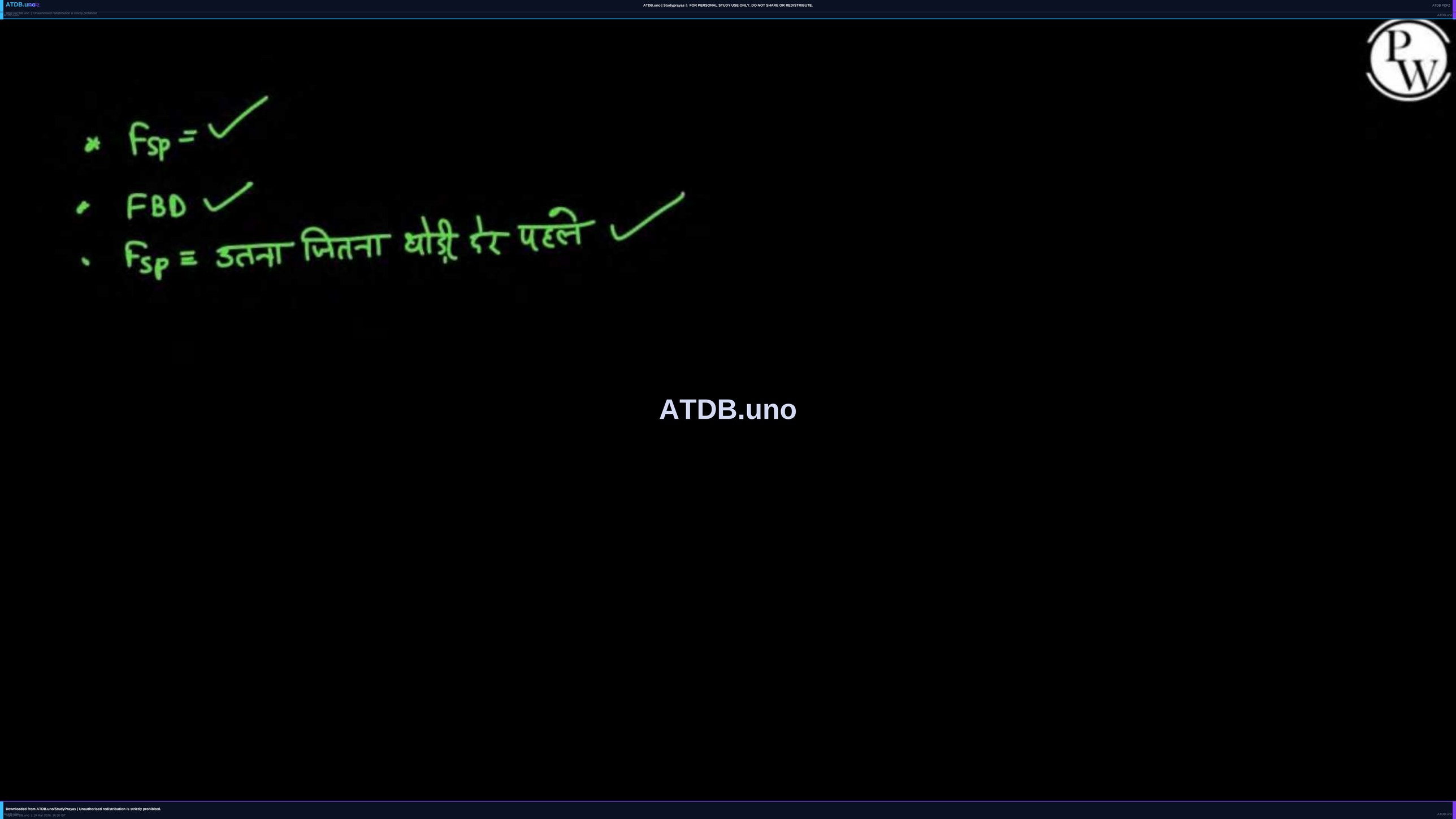


If at t=0, lower spring is cut find acc of each block just after cutting of spring. $t = 0^+$



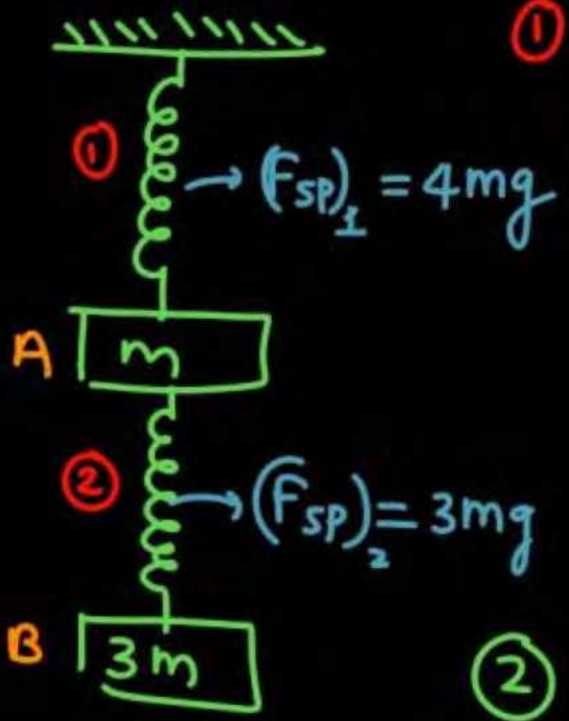
$\uparrow a_1 = \frac{300 - 100}{10} = 20$





ATDB.uno

Q2



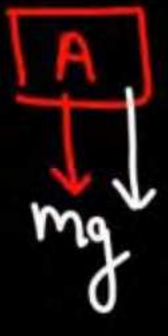
① If at t=0 Lower spring is cut find acc of each block

$a_B = g \downarrow$

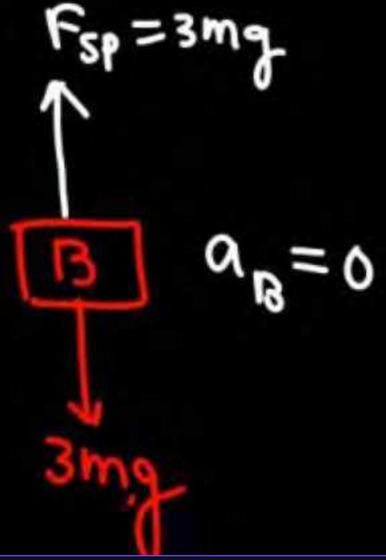
$F_{sp} = 4mg$

$a_A = \frac{4mg - mg}{m} = 3g \uparrow$

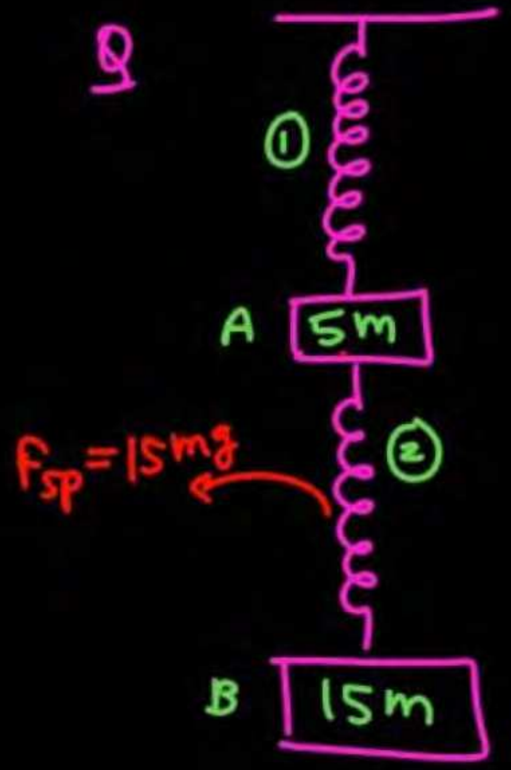
② If upper spring is cut



$a = \frac{4mg}{m} = 4g \downarrow$



Q

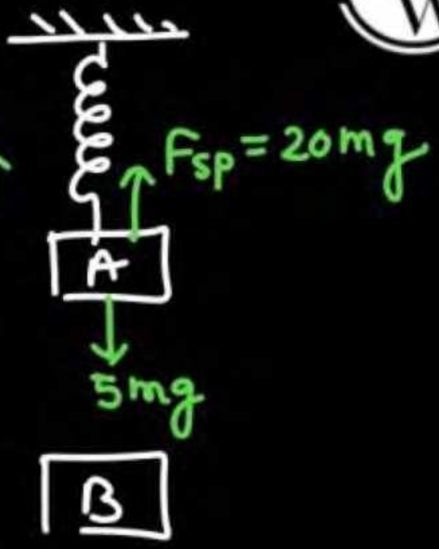


① If at $t=0$ spring 2 is cut find acc of A & B

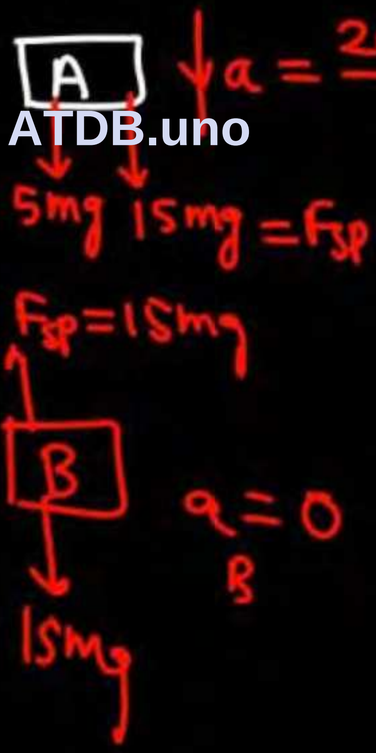
Lower spring cut

$t=0^+$, $a_B = g\downarrow$

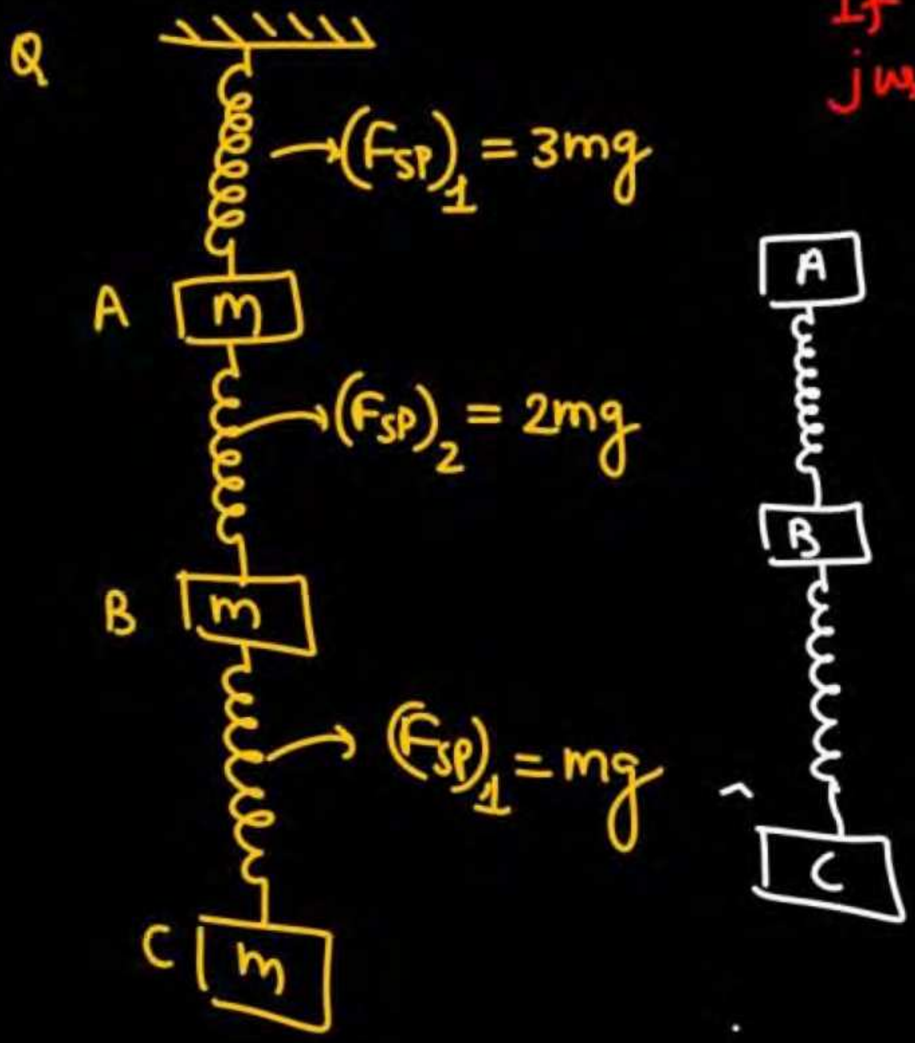
$a_A = \frac{15mg}{5m} = 3g\uparrow$

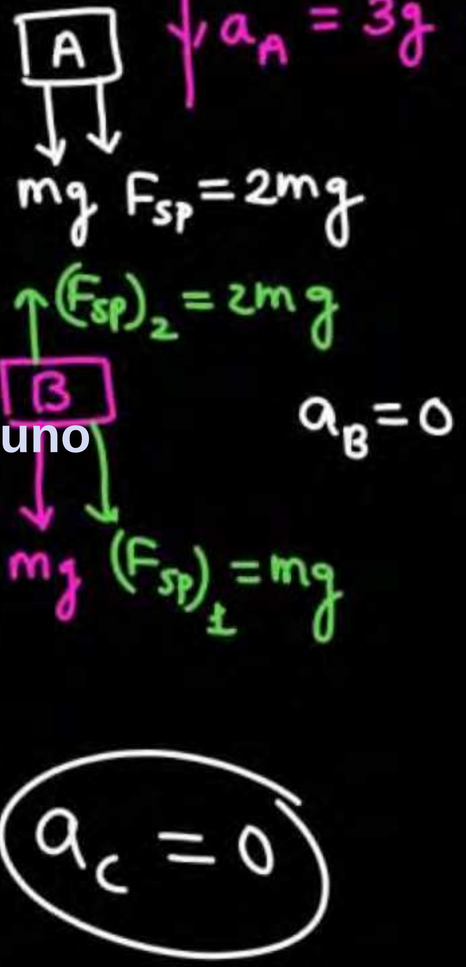


② If upper spring is cut



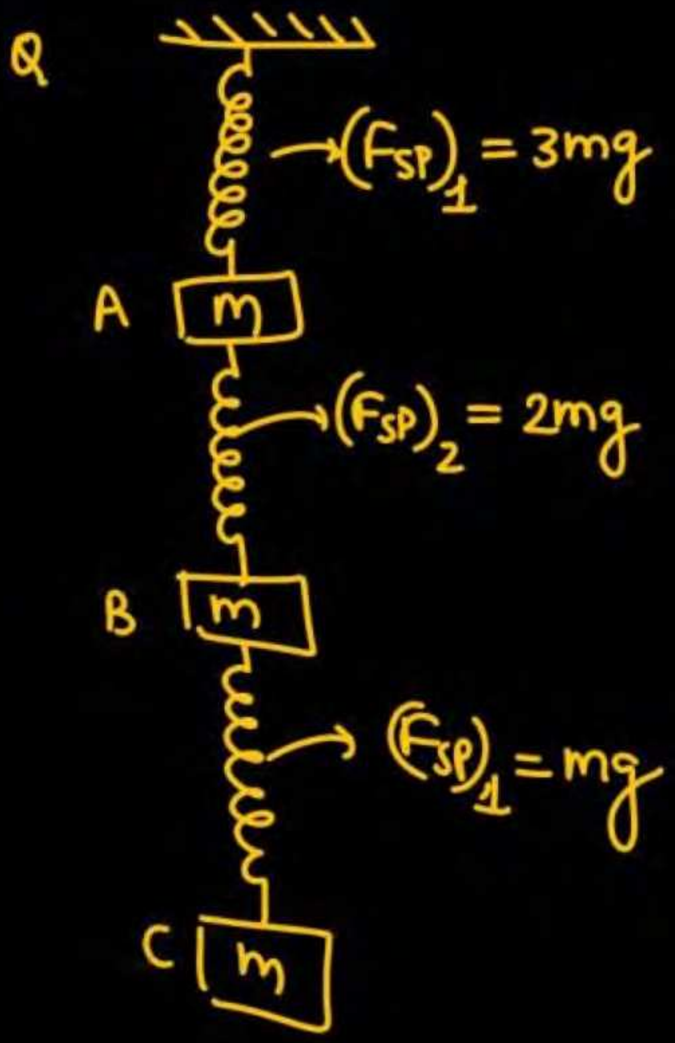
If upper spring is cut at $t=0$, find acc of A, B, C just after $t=0^+$

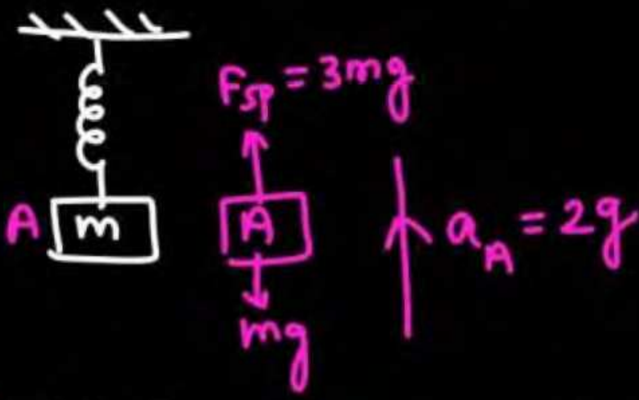


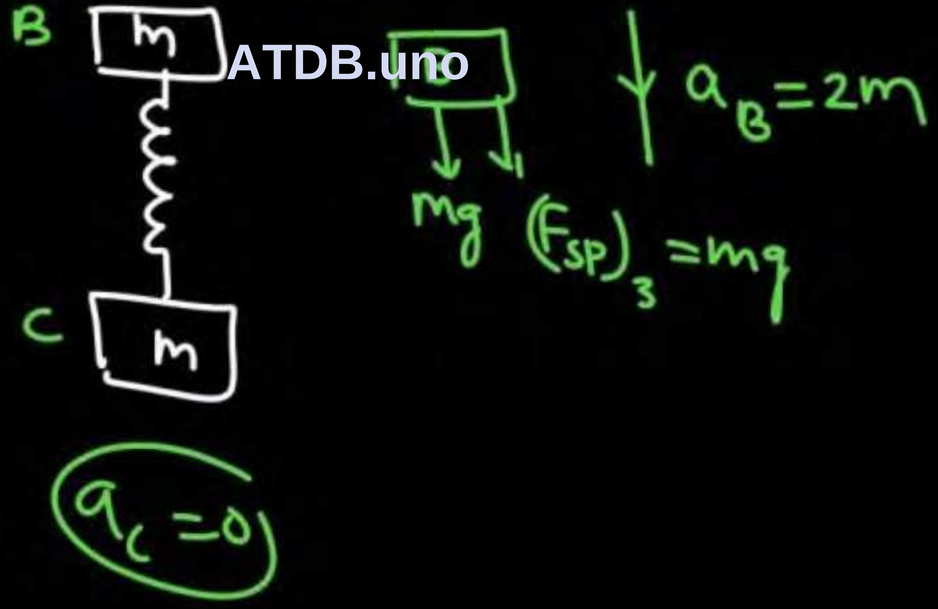


$a_C = 0$

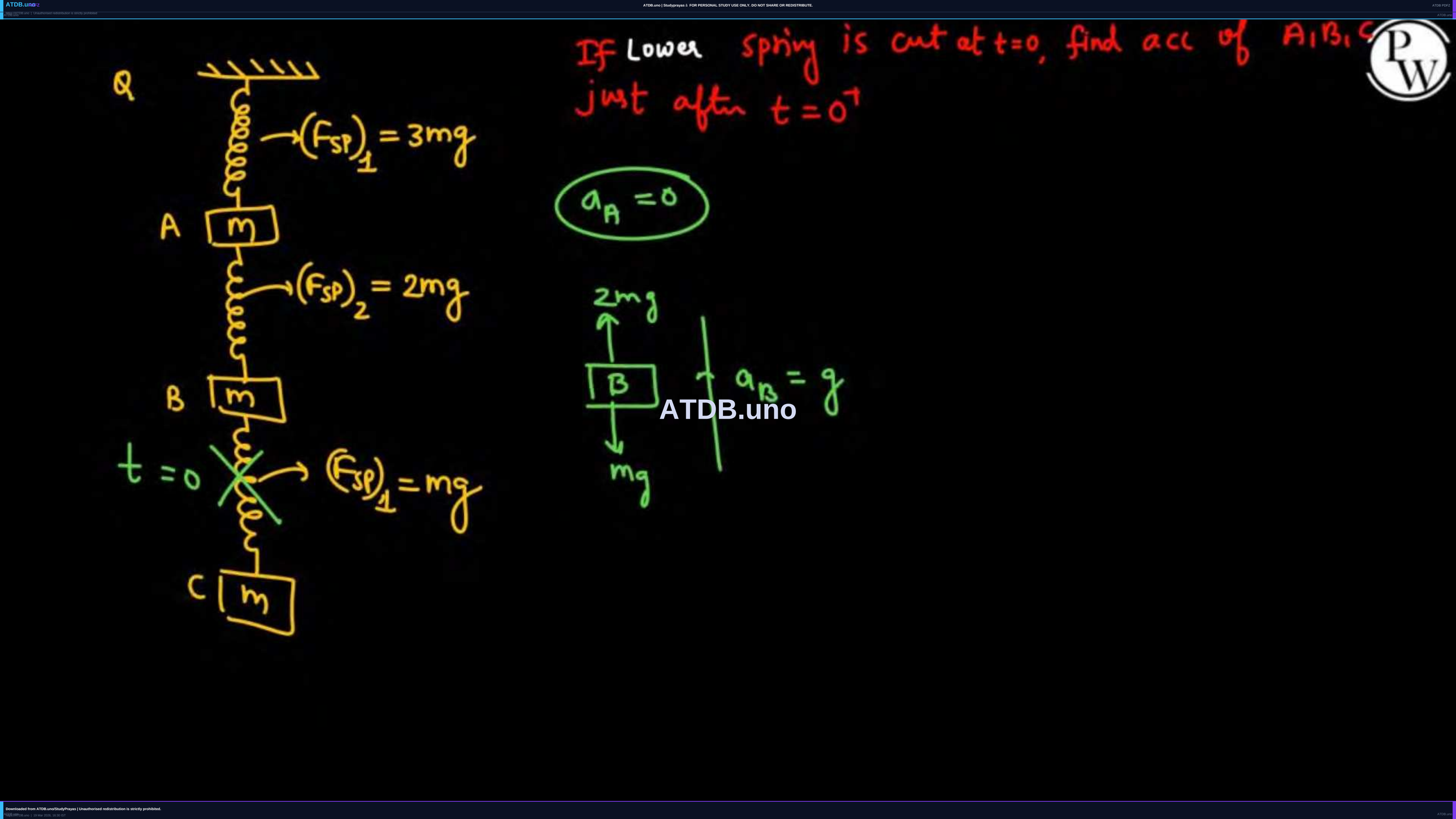
If middle spring is cut at $t=0$, find acc of A, B, C just after $t=0^+$

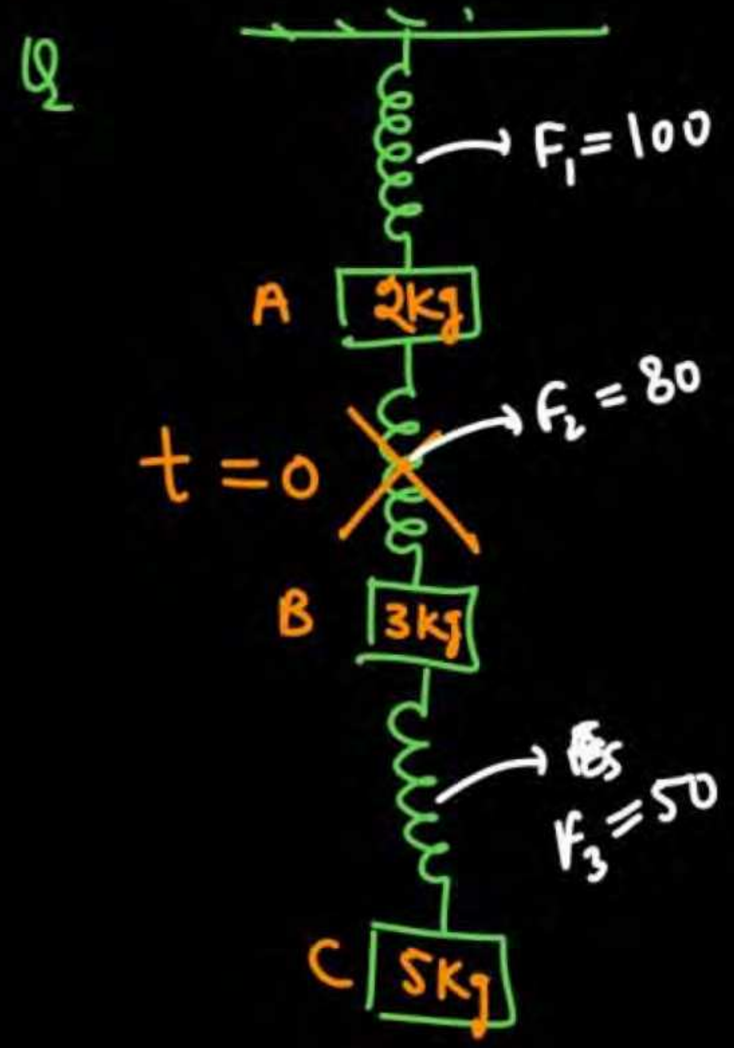






$a_C = 0$



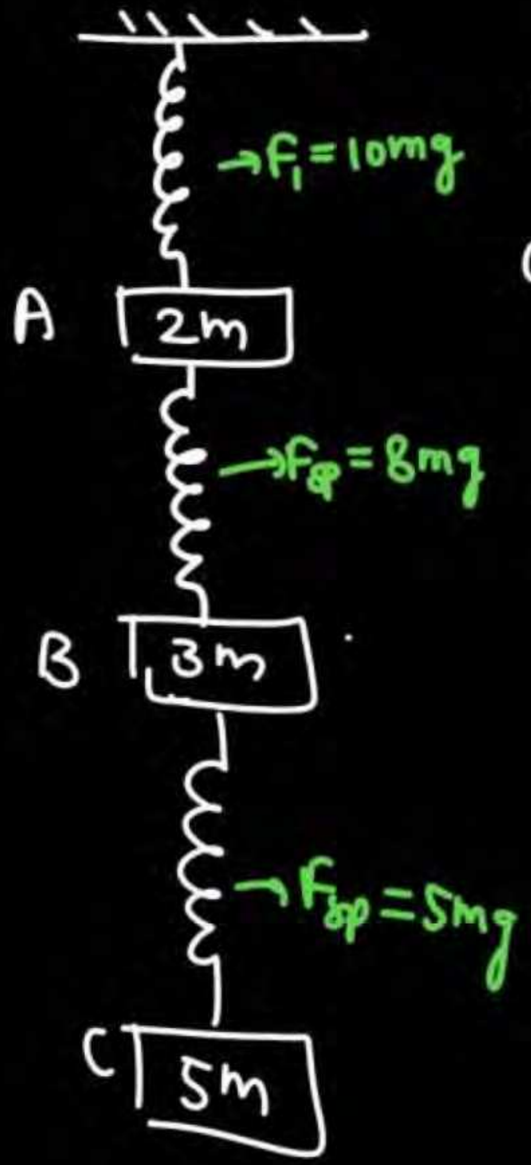


$$a_A = \frac{80}{2} = 40 \uparrow$$

$$a_B = \frac{80}{3} \downarrow$$

$$a_C = 0$$

Q



If middle spring is cut

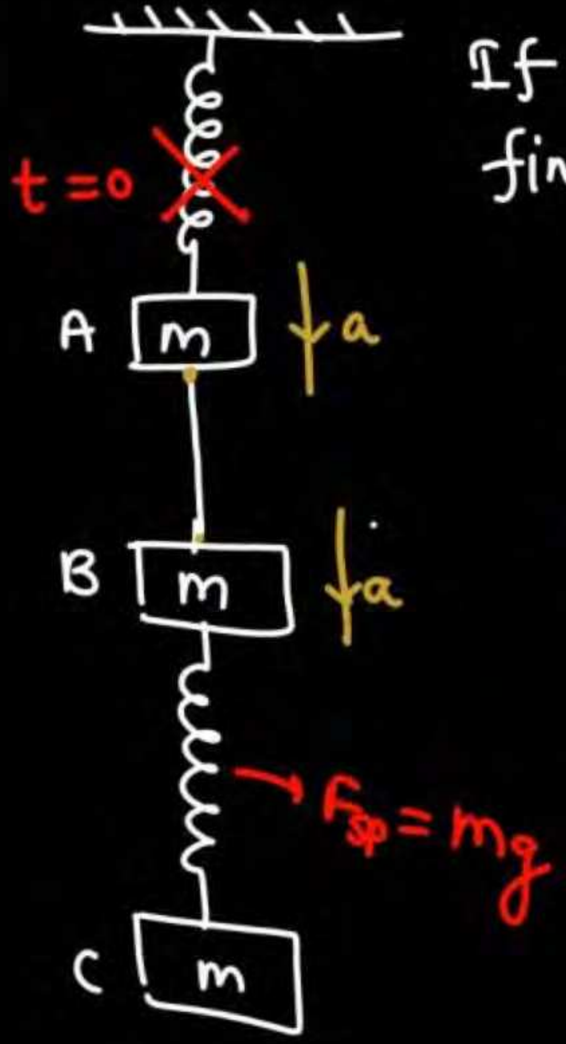
$a_A = \frac{8mg}{2m}$ $\quad a_B = \frac{8mg}{3m}$ $\quad a_C = 0$

If upper spring is cut

$a_A = \frac{10mg}{2m}\downarrow$ $\quad a_B = 0$

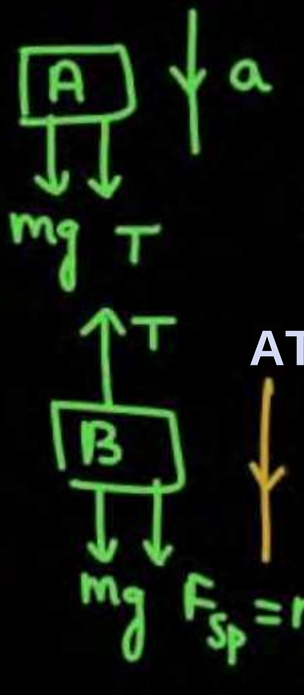
$a_C = 0$

Q



If upper spring is cut at $t=0$
find acc of each block just aftr $t=0^+$

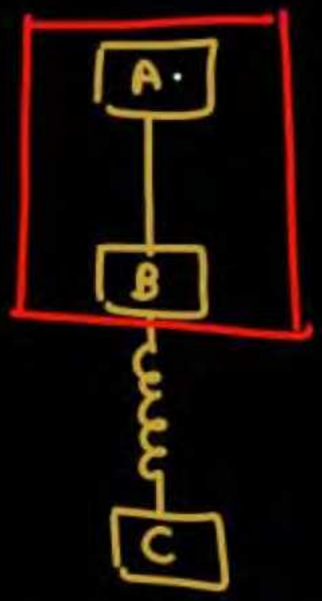
$a_C=0$

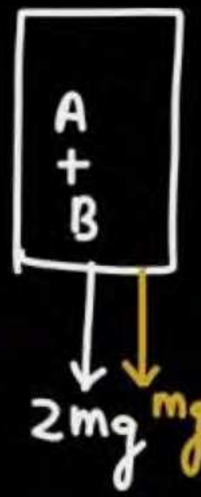


$mg+T=ma$

$2mg-T=ma$

$a=\frac{3g}{2}=a_A=a_B$

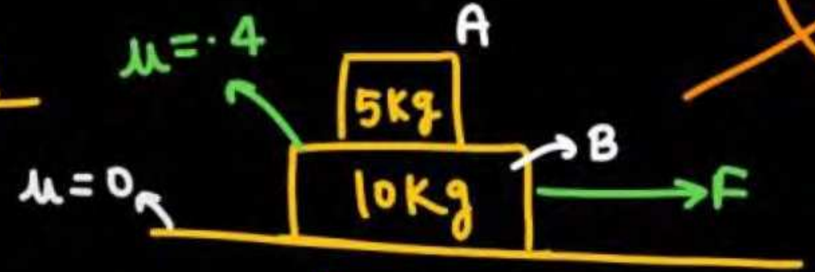




$a_A=a_B=\frac{3mg}{2m}$

Two Block Problem

Q



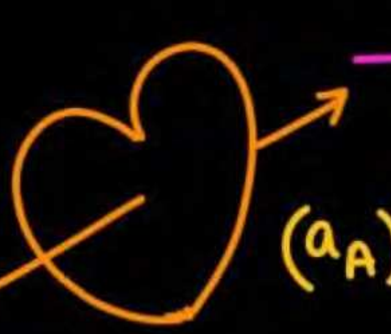
(a) Find max value of F so that Both block move together with same acc (without slipping)

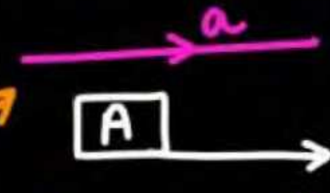
Sol

Ans

$F \leq 60$ साथ - ☺

$F > 60$ अलग - ☹

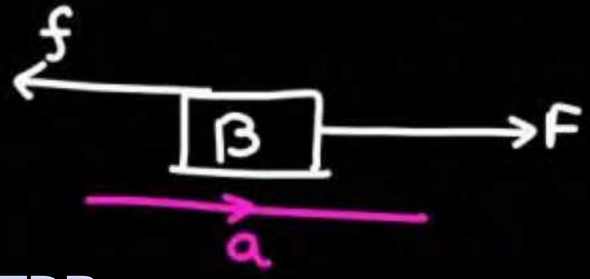




$(f_s)_{max} = \mu N$

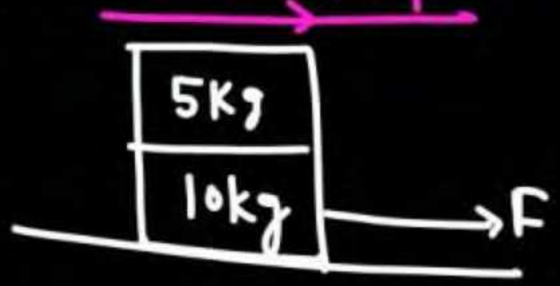
$= .4 \times 50 = 20$

$(a_A)_{max} = \frac{f_{max}}{m_A} = \frac{20}{5} = 4$



$(a_{common})_{max} = 4$

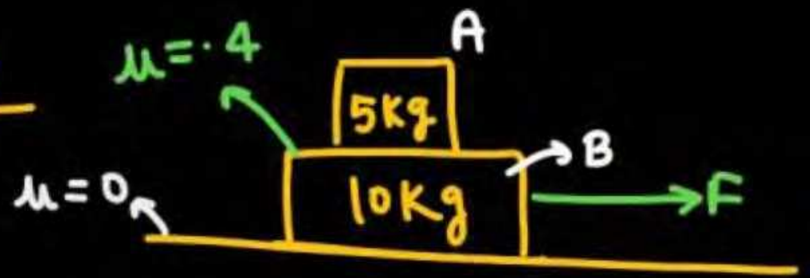
or



$F = 15 \times 4 = 60$

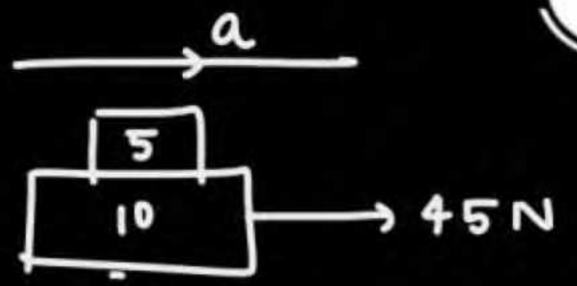
Two Block Problem

Q

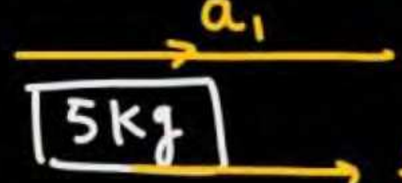


(b) If F = 45N

$$a_A = a_B = \frac{45}{15} = 3$$

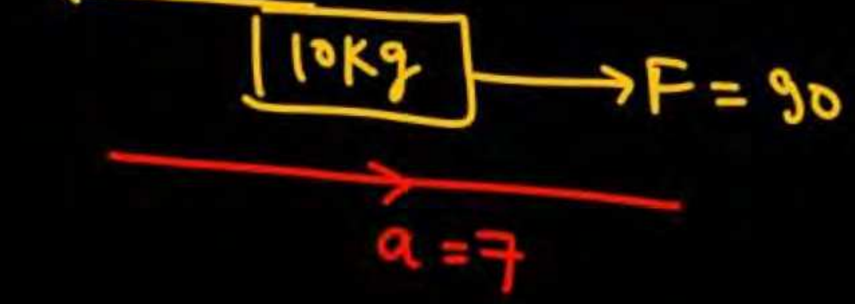


(c) F = 90 N ≡ अलग



$f_k = 20$

$$a_1 = \frac{f}{m} = \frac{20}{5} = 4$$



$F_{max} \equiv a_1 = a_2 \Rightarrow$ ✓ = साथ-साथ ✓

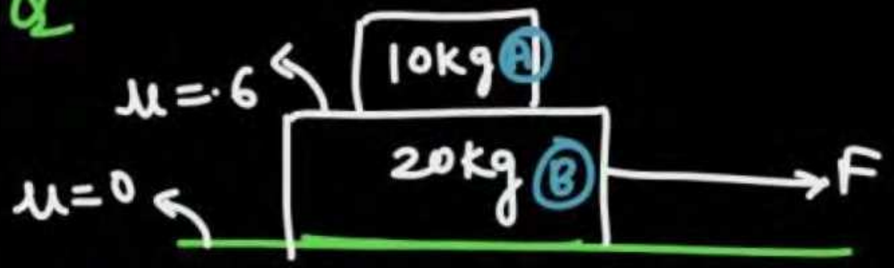
① $(f_s)_{max} =$ ✓

② $(a_{\text{मोहनाज}})_{max} = (a_{common})_{max}$ साथ-साथ

③ पूरे FBD ✓ $F_{net} = ma$ लगा दो

find F_{max} so that both move together

Q



$(f_s)_{max} = .6 \times 100 = 60$

$(a_A)_{max} = \frac{60}{10} = 6 = (a_{common})_{max}$

$F = (10+20) \times 6$

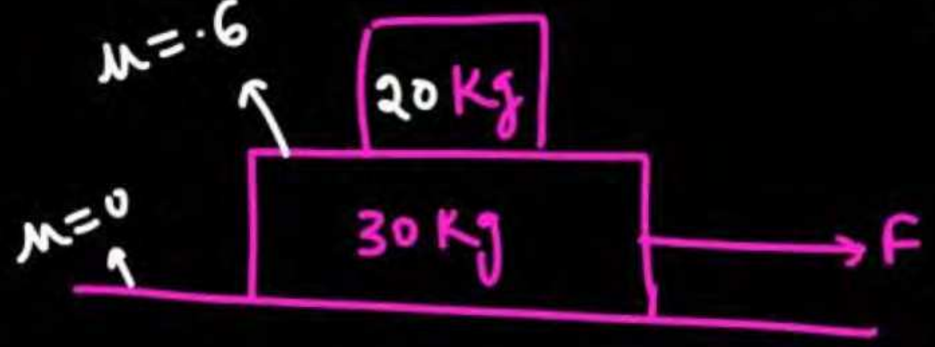
$F = 180\ N$

$F \leq 180$ $\quad a_1 = a_2$ together

$F > 180$ $\quad a_1 \neq a_2$, अलग-अलग Slipping

Repeat the last qun

Q

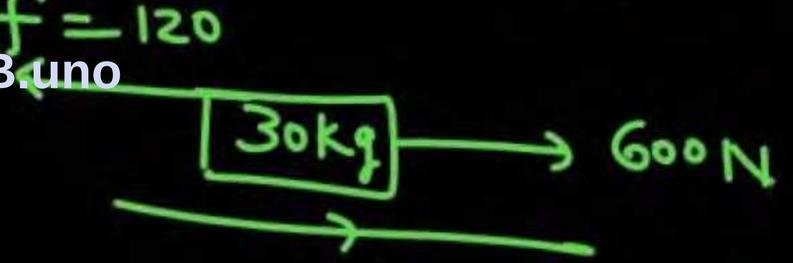


$F \leq 300$ साथ - 2

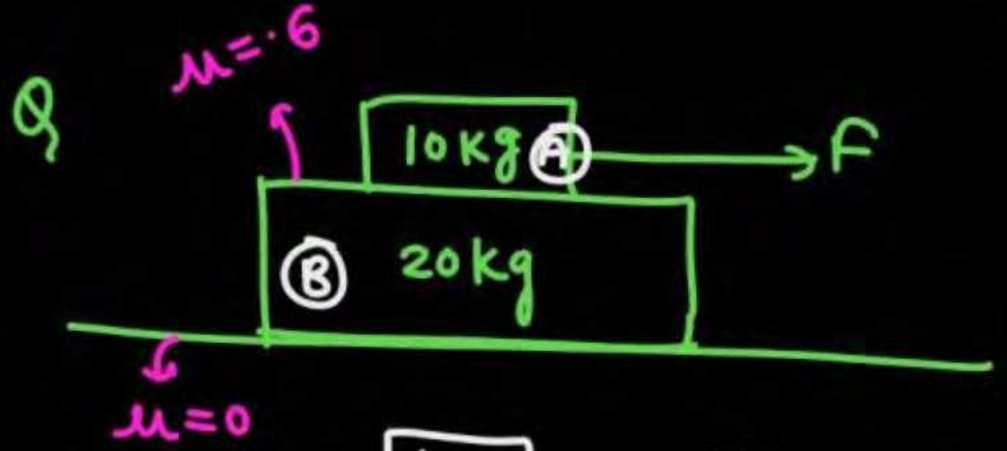
$F > 300$ अलग = 2

(b) If $F = 600\ N$

$$a_1 = \frac{120}{20} = 6$$



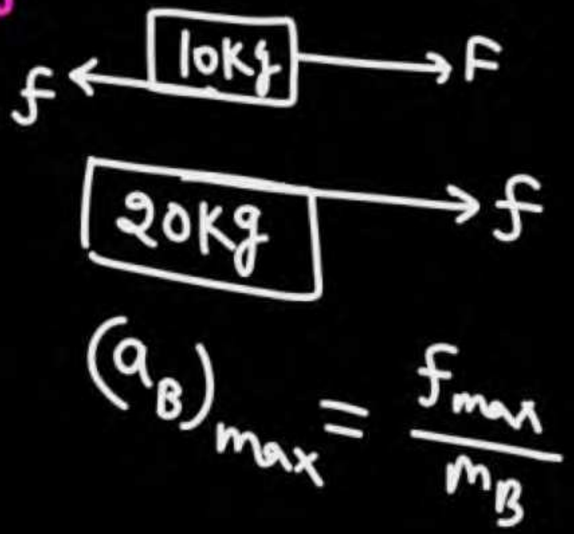
$$a_2 = \frac{600 - 120}{30}$$



find f_{max} so that both move together

$$(f_s)_{max} = \cdot 6 \times 100 = 60$$

$$(a_B)_{max} = \frac{60}{20} = 3 = (a_{comm})_{max}$$



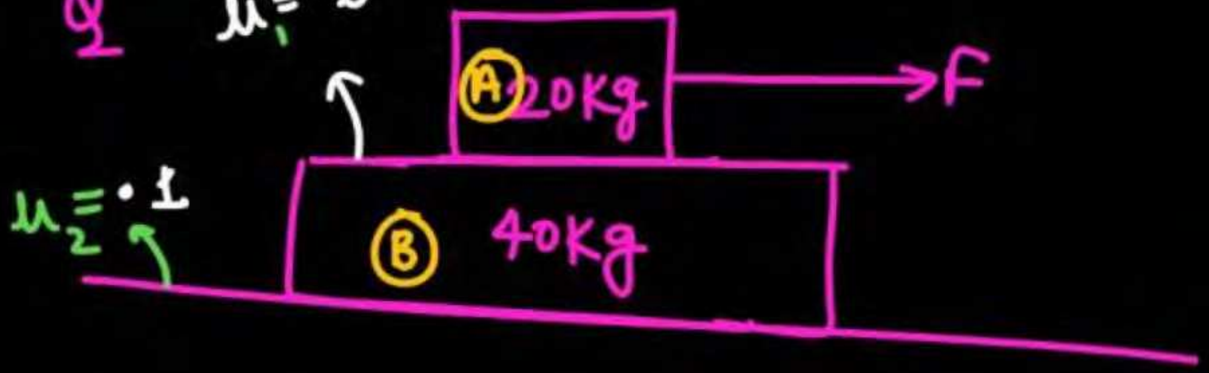
$$(a_B)_{max} = \frac{f_{max}}{m_B}$$

$$F = (10+20) \times 3 = 90$$

$F \leq 90$ together

$F > 90$ अलग-अलग

Q $\mu_1 = .6$



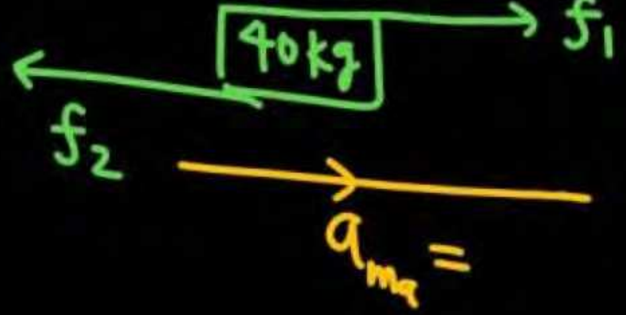
$\mu_2 = .1$

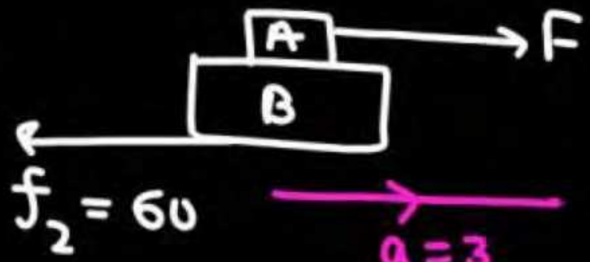
$(f_1)_{max} = .6 \times 200 = 120$

$(f_2)_{max} = \mu_2 N_{\text{जमीन}} = .1 \times 600 = 60$

$$(a_B)_{max} = \frac{(f_1)_{max} - f_2}{m} = \frac{120-60}{40} = \frac{3}{2}$$

$a_{common} = \frac{3}{2}$





$F - 60 = 60 \times \frac{3}{2}$

$F = 150$

$F \leq 60 \quad a_1 = a_2 = 0$

$60 < F \leq 150$ साथ-साथ

$F > 150$ अलग-अलग

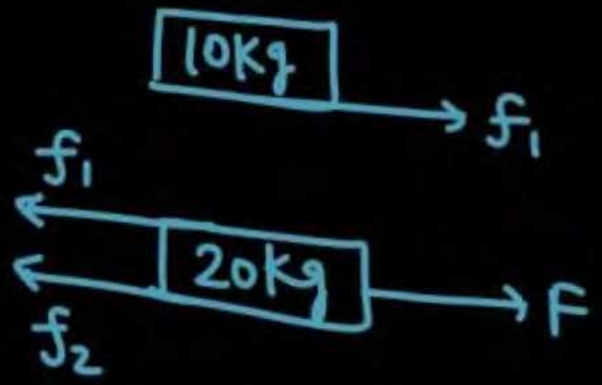
Q

Rest

$F \leq 60$ $a_1 = a_2 = 0$

$60 < F \leq 240$ साथ - $\frac{2}{3}$

$F \geq 240$ अलग - $\frac{2}{3}$



$(a_A)_{max} = \frac{60}{10} = 6 = a_{common}$

$F_{net} = m_{total}\, a_{com}$

$F - 60 = (10 + 20) \times 6$

$F = 240$

$(f_2)_K = .2 \times 300$

$= 60$