IIT – JEE: 2020 **TW TEST (3 YRS.)** **DATE: 13/05/18**

TOPIC: LOM & FRICTION

ANSWER KEY

1.	**(B)**	2.	**(B)**	3.	**(B)**	4.	**(A)**	5.	**(D)**
6.	**(ABC)**	7.	**(BC)**	8.	**(AB)**	9.	**(BC)**	10.	**(BD)**
11.	**(ABCD)**	12.	**(ABCD)**	13.	**(AB)**	14.	**(ABC)**	15.	**(ABD)**
16.	**(5)**	17.	**(8)**	18.	**(4)**	19.	**(4)**	20.	**(4)**

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ANSWER KEY

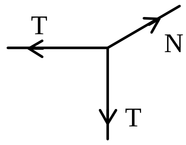
1. **(B)**

2. **(B)**

$mg - T = ma$

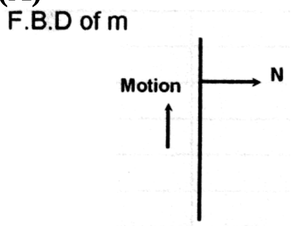
$T = ma$

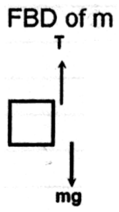
$\Rightarrow T = \frac{ma}{2}$ or $N = \frac{mg\sqrt{2}}{2}$



3. **(B)**

4. **(A)**





N = T and μmg downward.

5. **(D)**

6. **(ABC)**

If the tendency of relative motion along the common tangent does not exist, then component of contact force along common tangent will be zero.

7. **(BC)**

Here $F > \mu_8 mg\left(1 + \frac{m}{M}\right)$

For m

$f - \mu_k mg = m.a$

For M

$\mu_k mg = MA$

$A = 0.4 m/s^2$

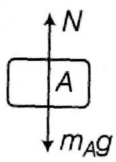
8. **(AB)**

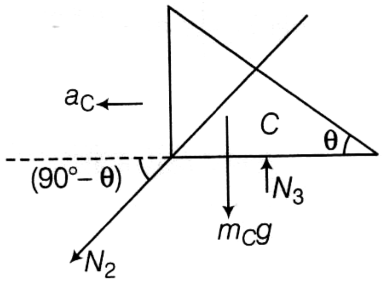
(A) From free body diagram of A,

$m_A g - N = m_A a_A$

Thus, the acceleration of block A is downward.

(B) Free body diagram of block C,





From free body diagram of block C,

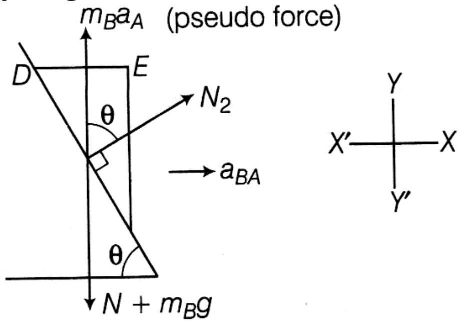
$$N_3 = m_C g + N_2 \cos\theta$$

And $N_2 \sin\theta = m_C a_C$ (in horizontal direction)

Thus, block C is accelerating horizontally leftward.

(C) $a_{Ba} = a_B - a_A$

Free body diagram of B in the frame of A,



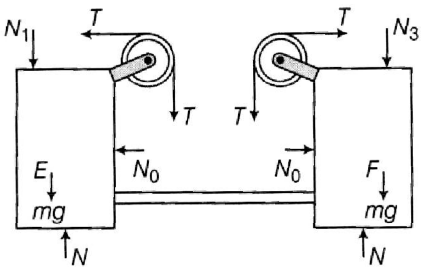
The acceleration of B with respect to A should be along the surface of contact DE.

∴ $N_2 \sin\theta = m_B a_{BA}$ (in rightward direction)

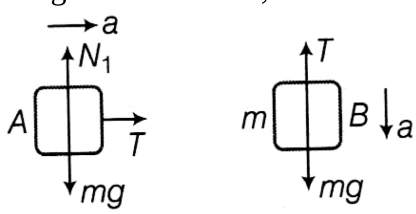
Hence, option (C) is incorrect.

9. **(BC)**

From free body diagram of block E + block F, net force is zero. The acceleration of blocks E and F are zero.



From free body diagram of block A,



$$T = ma$$

From free body diagram of block B,

$$mg - T = ma$$

∴ $mg = 2ma$

∴ $a = g/2$

Hence, options (B) and (C) are correct.

10. **(BD)**

When the draw is x.

Force $F = \frac{100}{0.4}x = 250x$

$\therefore$ $a = \frac{250x}{0.01} = 25000x$

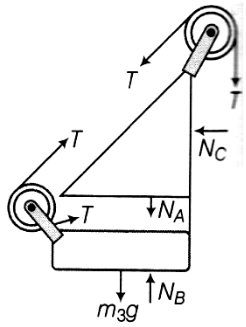
Or $\frac{vdv}{dx} = 25000$ or $\int_0^v vdv = 25000\int_0^{0.4} xdx$

Or $\frac{v^2}{2} = 25000 \times 0.08 = 2000$

Or $v = \sqrt{4000} = 20\sqrt{10}$ m/s

11. **(ABCD)**

Fro triangular block b,



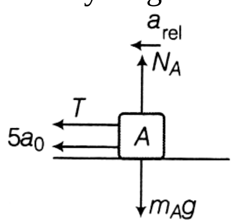
$T - N_C = 5a_0$ .....(i)

$N_B = N_A + T + m_B g$

or $N_B = m_a g + T + m_B g$

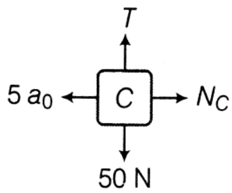
$\therefore$ $n_B = 100 + T$ ...(ii)

From free body diagram of block A in frame of block B,



$T + 5a_0 = 5a_{rel}$ .....(iii)

From free body diagram of block C in the frame of block B



$N_C = 5a_0$ .....(iv)

and $50 - T = 5a_{rel}$ .....(v)

From Eqs. (i), (iii), (iv) and (v)

$T - 5a_0 = 5a_0$

$\Rightarrow$ $T = 10a_0$

$T + 5a_0 = 5a_{rel}$ (from Eq. (iii))

$15a_0 = 5a_{rel}$

$\Rightarrow$ $a_{rel} = 3a_0$

$50 - T = 5a_{rel}$ (from Eq.(v))

$50 - 10a_0 = 15a_0$

$\Rightarrow$ $50 = 25al0$

$\therefore$ $a_0 = 2\ m/s^2$

$\therefore$ $T = 10 \times 2 = 20\,N$

$a_{rel} = 3a_0 = 6\ m/s^2$

$N_B = 100 + T = 100 + 20 = 120\,N$

12. **(ABCD)**

$m_D g = (m_B + m_C + m_D)a \Rightarrow a = 5\,m/s^2$

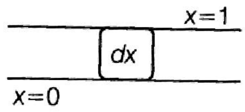
$T_{BC} = m_B a = 1 \times 5 = 5\,N$

and $\quad m_D g - TlCD = 2 \times 5$

$\therefore \quad T_{CD} = 20 - 10 = 10\,N$

13. **(AB)**

The linear mass density of the rod at distance x is $\lambda = 1 + x$



$m = \int dm = \int_0^1 \lambda\, dx = \int_0^1 (1+x)\,dx$

$= 1 + \frac{1}{2} = 1.5\,kg$

Thus, friction is $f = \mu_k mg = 1.5 \times 0.5 \times 10 = 7.5\,N$

$\therefore \quad a = \frac{F - 7.5}{m} = \frac{15 - 7.5}{\frac{3}{2}} = \frac{2 \times 7.5}{3} = 5\,m/s^2$

14. **(ABC)**

Concept If $F \le \mu_s mg$, applied force F is balanced static friction. Thus, tension in string is zero.

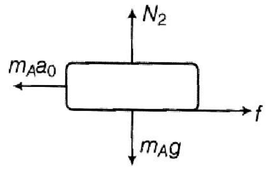
If $F > \mu_s mg$, friction is limiting friction. Thus, $F = T + f_{max}$,

$\therefore \quad T = F - \mu_s mg$.

15. **(ABD)**

(A) Common acceleration $(a_0) = \frac{F}{m_A + mlb} = \frac{9}{3} = 3\,m/s^2$

Free body diagram of block A in the frame of block B is shown below,



$(f_s)_{max} = \mu_s N_2 = 0.5 \times 1 \times 10 = 5\,N$

Also, $\quad m_A a_0 = 1 \times 3 = 3\,N$

$\because m_A a_0 < (f_S)_{max}$, the blocks will move forward with common acceleration and static friction exists between A and B.

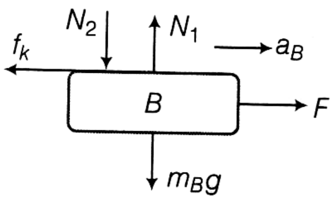
$f = m_A a_0 = 3\,N$

(B) $\quad a_0 = \frac{16}{3} = 5.33\,m/s^2$

$m_A a_0 = 1 \times \frac{16}{3} = 5.33\,N$

$\because (m_A al0) > (f_s)_{max}$, there will be relative between the blocks and kinetic friction acts between A and B.

Free body diagram of block B is shown,



$F - f_k = m_B a_B$

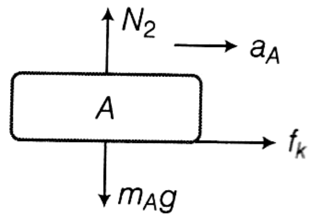
Or $\quad F - \mu_k N_2 = m_B a_B \quad .....(i)$

Also, $N_2 = m_a g$ .....(ii)

From, Eqs. (i) and (ii), we get

$$a_B = \frac{F - \mu_k m_A g}{m_B}$$

or $a_B = \frac{16 - 0.4 \times 1 \times 10}{2} = 6\,m/s^2$



free body diagram of A in the frame of ground.

$f_k - m_A a_A$

or $a_A = \frac{f_k}{m_A} = 4\,m/s^2$

(D) $\frac{F - \mu_k m_A g}{m_B} = a_B$ .....(i)

Also, $f = \mu_k m_A g = m_A a_A$

Or $a_A = \mu_k g$ .....(ii)

Combining Eqs. (i) and (ii),

Consider, $a_B > a_A \Rightarrow \frac{F - \mu_k m_A g}{m_b} > \mu_k g$

Or $F > \mu_k g (m_A + m_B)$

Hence, $a_B > a_A$ for $F > \mu_k g (m_A + m_B)$

16. **(5)**

17. **(8)**

18. **(4)**

19. **(4)**

$F_r = F_{applied}$

When F applied in lesser than limiting friction.

20. **(4)**