WEEKLY TEST MEDICAL PLUS -01 TEST - 11 Balliwala SOLUTION Date 28-07-2019

[PHYSICS]

1. Given that $U = \frac{A}{r^2} - \frac{B}{r}$

For stable equilibrium,

$$F = -\frac{dU}{dr} = 0$$

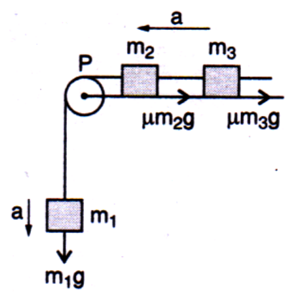
or $$-\frac{2A}{r^3} + \frac{B}{r} = 0$$

or $$\frac{2A}{r^3} = \frac{B}{r} \quad \text{or} \quad r = \frac{2A}{B}$$

2. Force of friction on mass $m_2 = \mu m_2 g$

Force of friction on mass $m_3 = \mu m_3 g$

Let a be common acceleration of the system



$$\therefore \quad a = \frac{m_1 g - m_2 g - \mu m_3 g}{m_1 + m_2 + m_3}$$

Here, $m_1 = m_2 = m_3 = m$

$$\therefore \quad a = \frac{mg - \mu mg - \mu mg}{m + m + m}$$

$$= \frac{mg - 2\mu mg}{3m}$$

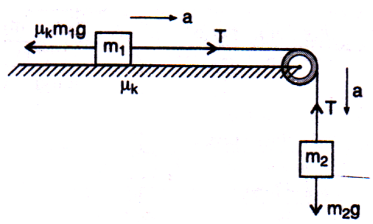
$$= \frac{g(1-2\mu)}{3}$$

3. For motion of mass m_1,

$T - \mu_k m_1 g = m_1 a$ ......(i)

$m_2 g - T = m_2 a$ ....(ii)

Adding eqns. (i) and (ii), we get



$$a = \frac{m_2 g - \mu_k m_1 g}{m_1 + m_2} \quad ....(iii)$$

Putting eqn. (iii), in eqn. (ii), we get

$$m_2 g - T = m_2 \left[\frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}\right]$$

or $$T = \left[\frac{m_1 m_2 g(1+\mu_k)}{m_1 + m_2}\right]$$

4. Pseudo force or fictitious force, $F_{fic} = m\alpha$

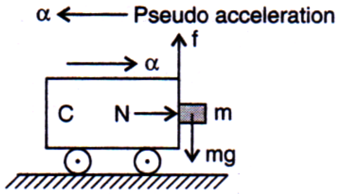
Force of friction, f = μN = $\mu m\alpha$

The block of mass m will not fall as long as :

$f \geq mg$

$\mu m\alpha \geq mg$

$$\alpha \geq \frac{g}{\mu}$$



5. Force of friction, f = μmg

$$\therefore \quad a = \frac{f}{m} = \frac{\mu mg}{m} = \mu g = 0.5 \times 10 = 5ms^{-2}$$

Using, $v^2 - u^2 = 2aS$

$0^2 - 2^2 = 2(-5) \times S$

S = 0.4 m

6.

7. R = mg cosα

Force of friction = μR = μmg cosα

Force on the body along the direction of motion

= mg sinα – μmg cosα

$$\therefore \quad a = \frac{force}{mass} = g(\sin\alpha - \mu\cos\alpha)$$

8.

9. When a man walks on a rough surface, it is the frictional force which is responsible for motion, i.e., required angle between frictional force and ionstaneous velocity is zero

10. Vehicles are streamlined to reduce the frictional force offered by the surrounding air, i.e., reduce the fluid friction (also called WET friction). Friction between fluid and solid is called as wet friction.

11. Ball bearing are helpful in converting the sliding friction into rolling friction. Remember rolling friction is negligble as compared to sliding friction.

12. The forward tension on the tail bogey is least and hence the tail bogey is brought to rest first

13. When the cube is to be moved up, the minimum force needed is given by :

F = mg sinθ + μR = mgsinθ + μmgcosθ

$$= 10\sin\theta + 0.6 \times 10\cos\theta = 10 \times \frac{3}{5} + 0.6 \times 10 \times \frac{4}{5}$$

= 10.8 N

14. The retardation a is given by :

$$a = g\sin 45^o + \mu g\cos 45^o = \frac{g}{\sqrt{2}} + \frac{1}{2}g \times \frac{1}{\sqrt{2}}$$

$$= \frac{g}{\sqrt{2}}\left(1 + \frac{1}{2}\right)$$

15. Coefficient of static friction $\mu_s = (f_L R)$

When R is doubled, f_L or applied force F is also doubled so that μ_s remains same.

16. When the angle of inclination is equal ot angle of repose, the body just slides down the plane. But when the angle of inclination is greater than the angle of repose, the body begins to accelerate down the plane.

17. $\mu_s > \mu_k > \mu_r$. Rolling friction is always less than sliding friction, that is why it is easy to move heavy load from one place to another by rolling it over the surface instead of sliding it over the same surface. Moreover, it is quite obvious that static friction is always greater than kinetic friction

18. Proper inflation of the types reduces the area of contact between the tyre and road which in turn helps in decreasing the force of adhesion between two surfaces.

19. Given u = V, final velocity = 0

Using v = u + at

$\therefore$ 0 = V – at or $-a = \frac{0-V}{t} = -\frac{V}{t}$

f = μR = μmg (f is the force of friction)

$\therefore$ Retardation, a = μg

$\therefore$ $t = \frac{V}{a} = \frac{V}{\mu g}$

20. There occurs a loss in mass at the rate of Δm.Δt.

Hence, loss in mass in time $t = \frac{\Delta m}{\Delta t} \times t$

Mass of the rocket after time $t = M_0 - \frac{\Delta m}{\Delta t} \times t$

21.

22. $F_x = -\frac{dU}{dx} = -a$ and $F_y = -\frac{dU}{dy} = -b$

$F = \sqrt{F_x^2 + F_y^2} = \sqrt{a^2 + b^2}$

Acceleration, $\frac{F}{m} = \frac{\sqrt{a^2 + b^2}}{m}$

23. $x = 3t - 4t^2 + t^3$

$\frac{dx}{dt} = 3 - 8t + 3t^2$ and $a = \frac{d^2x}{dt^2} = -8 + 6t$

Now, $W = \int F dx \int madx = \int ma \frac{dx}{dt} dt$

$= \int_0^4 \frac{3}{1000} \times (-8 + 6t)(3 - 8t + 3t^2)dt$

On integrating, we get W = 530 mJ

24. The customer gets $\frac{W_1 + W_2}{2}$ instead of $\sqrt{W_1 W_2}$

Now, $\frac{W_1 + W_2}{2} - \sqrt{W_1 W_2} = \left[\frac{W_1 + W_2 - 2\sqrt{W_1 W_2}}{2}\right]$

$= \frac{(\sqrt{W_1} - \sqrt{W_2})^2}{2}$

As $(\sqrt{W_1} - \sqrt{W_2})^2$ is +ve, hence the customer gets more than his due and the tradesman loses.

25. If the applied force is increased beyond the force of limiting friction and the body starts moving, the friction opposing the motion is caleld kinetic or sliding or dynamic friction. Experimentally, it is also well established that dynamic friction is lesser than the limiting static friction and is given by

$f_k = \mu_k R$.

where μ_k is called coefficient of kinetic friction

26. When the body is rest, force of friction between the body and the floor = applied force = 2.8 N.

27.

28. Kinetic friction is constant, hence frictional force will remain same = (10 N)

29. The force on the block due to acceleration of the truck will be opposite to the acceleration of the truck and will be F = ma = 1 × 5 = 5 N

While the limiting friction

$f_L = \mu R = \mu mg = 0.6 \times 1 \times 9.8 = 5.88$ N

As applied force $F < f_L$, the block will reamin at rest in the truck and force of friction will be equal to applied force of 5 N (and not f_L) in the direction of acceleration of the truck.

30. Given that; $a = 70\text{km/h} = 70 \times \frac{5}{18} = \frac{175}{9}\text{m/s}$

Final velocity = 0

Now, $\mu = \frac{F}{R} = \frac{(m-a)}{mg} = -\frac{a}{g}$ or $-a = \mu g$

∴ Retardation = 0.2 × 9.8 = 1.96 m/s^2

Using, $v^2 = u^2 + 2as$, we get

$$0 = \left(\frac{175}{9}\right)^2 + 2(-1.96)s$$

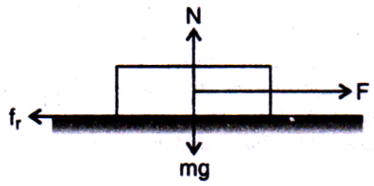
Solving, we get; s = 96.45 m

31.

32. $v = g(\sin\theta - \mu\cos\theta)t$

$$= 10\left[\frac{1}{2} - (0.2)\frac{\sqrt{3}}{2}\right]5 = 16.34 \text{ ms}^{-1}$$

33.

34. 

$F = f_r = \mu N = \mu mg = 0.1 \times 1 \times 9.8 = 0.98$ N

(Assuming that the value of μ = 0.1 is the coefficient of static friction)

35. $\frac{dM}{dt} = 0.1\text{kg/s}$, v_{gas} = 50 m/s,

mass of the rocket = 2 kg, Mv = consant

$$-v\frac{dM}{dt} + M\frac{dv}{dt} = 0 \qquad \therefore \frac{dv}{dt} = \frac{1}{M}v\frac{dM}{dt}$$

or acceleration $= \frac{1}{2} \times 50 \times 0.1 = 2.5 \text{ m/s}^2$

36. According to work-energy theorem

T = fy

where f is the frictional force exerted on the body

or $f = \frac{T}{y}$

[Note : One can also verify that $\frac{T}{y}$ has the dimension of force,

i.e., $\frac{[T]}{[y]} = \frac{[ML^2T^{-2}]}{[L]}$

$= [MLT^{-2}]$

37. $v = \sqrt{gr} = \sqrt{10 \times 40} = 20ms^{-1}$

38. Change in momentum,
$\Delta p = mv - (-mv) = 2mv$
$= 2 \times 0.25 \times 10 = 5$ kg ms^{-1}
Force × Time = Change in momentum

$\therefore$ $\text{Force} = \dfrac{\text{Change in momentum}}{\text{Time}}$

$= \dfrac{5kgms^{-1}}{0.01s} = 500$ N

39.

40.

41. Equal force will be exerted on both the cars. Hence, if a_1 and a_2 be the accelerations, then
$M_1a_1 = M_2a_2$

Also, $x_1 = \dfrac{v_1^2}{2a}$ and $x_2 = \dfrac{v_2^2}{2a_2}$

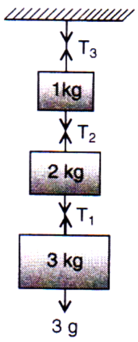
Therefore,

$$\frac{x_1}{x_2} = \frac{v_1^2}{v_2^2} \times \frac{a_2}{a_1} = \left(\frac{M_2}{M_1}\right)^2 \times \frac{M_1}{M_2} = \frac{M_2}{M_1} \qquad (\because M_1v_1 = M_2v_2)$$

Hence, $M_1x_1 = M_2x_2$

42. Suppose the force on the block be P and acceleration of the system be a. Then

$a = \dfrac{F}{(M+m)}$ and $P = Ma = \dfrac{MF}{(M+m)}$



43. From the figure, it follows that
$T_1 = 3g$
$2g + T_1 = T_2$
or $T_2 = 2g + 3g$
$= 5g$

44. Equation of motion are :
$m_1g - T = m_1a$
and $T - m_2g = m_2a$,
where T is the tension in the string
$(m_1 - m_2)g = (m_1 + m_2)a$

or $a = \dfrac{(m_1 - m_2)}{(m_1 + m_2)}g$

Putting the value of a in one of above equations,

$T = \dfrac{2m_1m_2}{(m_1 + m_2)}g$

$\therefore$ Thrust on the pulley $= 2T = \dfrac{4m_1m_2g}{(m_1 + m_2)}$

45.

[CHEMISTRY]

79.

22.4 L of N_2 at stp ≡ 28 g of N_2
1 L of N_2 at stp ≡ 1.25 g of N_2 and 22.4 L of O_2 at stp = 32 g of O_2.
7/8 litre of O_2 at stp ≡ 1.25 g of O_2.
$\therefore\ M_{N_2} = M_{O_2}$.

80.
82.

Using $n_1T_1 = n_2T_2$, $T_2 = \frac{n_1}{n_2}T_1 = \frac{n}{(1-3/8)n} \times 300 = \frac{n}{(5/8)n} \times 300 = 480$ K.

$\therefore\ T_2 = 207°C$.

83.

Volume of O_2 diffused $= \frac{22400 \times 0.48}{32} = 336$ mL.

Let the volume of CO_2 diffused be x mL.

Rate of diffusion of $O_2 = \frac{336}{1200}$ mL s^{-1}.

Rate of diffusion of $CO_2 = \frac{x}{1200}$ mL s^{-1}.

$$\frac{r_{O_2}}{r_{CO_2}} = \frac{V_{O_2}/t}{V_{CO_2}/t} = \sqrt{\frac{M_{CO_2}}{M_{O_2}}}$$

or $\frac{\frac{336}{1200}}{\frac{x}{1200}} = \sqrt{\frac{44}{32}}$.

$\therefore\ x = 286.5$ mL

84.
85.

$(U_{rms})_1 = \sqrt{\frac{3RT_1}{M_1}}$ for N_2 molecule, mol. wt. $M_1 = 28$.

$(U_{rms})_2 = \sqrt{\frac{3RT_2}{M_2}}$ for N atom, $M_2 = 14$.

$$\frac{(U_{rms})_1}{(U_{rms})_2} = \frac{\sqrt{\frac{3RT_1}{M_1}}}{\sqrt{\frac{3RT_2}{M_2}}} = \sqrt{\frac{3RT_1}{M_1} \times \frac{M_2}{3RT_2}} = \sqrt{\frac{T_2 \times 14}{28 \times 2T_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2}.$$

$(U_{rms})_2 = 2(U_{rms})$.

86.

The van der Waals equation for n moles of a real gas is given by

$$\left(p+\frac{n^2a}{V^2}\right)(V-nb)=nRT \quad \text{or} \quad \left(p+\frac{a}{V_m^2}\right)(V_m-b)=RT,$$

where V_m = molar volume = V/n.

At low pressure, V_m is high and so b can be neglected.

The $\left(p+\frac{a}{V_n^2}\right)V_m=RT$ or $pV_m=\frac{a}{V_m}=RT$

$\Rightarrow pV_m=RT-\frac{a}{V_m}$ $\Rightarrow \frac{pV_m}{RT}=Z=1-\frac{a}{RTV_m}$.

$Z=1-\frac{ab}{RT}$ $\left(\because V\propto\frac{1}{p}\right)$.

87.

For n moles of a real gas, the van der Waals equation becomes

$$\left(p+\frac{a}{V_m^2}\right)(V_m-b)=RT$$

At high temperature and low pressure, V_m is large in comparison to b and $\frac{a}{V_m^2}$ is negligibly small in comparison to p. Hence the above equation is reduced to $pV_m=RT$.

88.

89.

90.

The less the value of a, the weaker is the intermolecular attraction.