LAKSHYA ADVANCED UNIT TEST (LAUT)

00 – 00		PCM - 27.09.15	
Test No : 2105	3 Hrs.		

Hints & Solutions

PART A - PHYSICS

SECTION I - MULTIPLE ANSWER CORRECT TYPE

1. **b) If $m_1 = m_2$, the mass m_1 first begins to move up the inclined plane when the angle of inclination is θ, then μ = sec θ – tan θ.**

d) If $m_1 = 2\,m_2$, the mass m_1, first begins to slide down the plane if $\mu = \tan\theta - \frac{1}{2}\sec\theta$.

The block m_1 will just begin to move up the plane if the downward force m_2g due to mass m_2 trying to pull the mass m_1 up the plane just equals the force ($m_1g\sin\theta + \mu m_1 g\cos\theta$) trying to push the mass m_1 down the plane, i.e. when

$m_2g = m_1g(\sin\theta + m\cos\theta)$

Now, it is given that $m_1 = m_2 = m$.

Therefore, we have

$$1 = \sin\theta + m\cos\theta$$

$\Rightarrow \quad m = \sec\theta - \tan\theta$

The block m_1 will just begin to move down the plane if the downward force ($m_1g\sin\theta - \mu m_1 g\cos\theta$) on m_1 just equals the upwards force m_2g acting on m_1 due to m_2, i.e. if

$$m_2g = m_1g(\sin\theta - \mu\cos\theta)$$

or $\dfrac{m_1}{m_2} = \dfrac{1}{\sin\theta - \mu\cos\theta}$

If $m_1 = 2m_2$, then we have

$$2 = \frac{1}{\sin\theta - \mu\cos\theta}$$

$\Rightarrow \quad \mu = \tan\theta - \dfrac{1}{2}\sec\theta$

Hence the correct choices are (b) and (d)

2. **a) $l = \dfrac{\mu L}{(l + \mu)}$**

c) If μ = 0.25, $\dfrac{l}{L}$ = 20%

Let M be the mass of the chain and L its length. If a length l hangs over the edge of the table, the force pulling the chain down is $\dfrac{Ml}{L}$g. The force of friction between the rest of the chain of length (L – l) and the table is $\dfrac{\pi M(L-l)}{L}$g. For equilibrium, the two forces must be equal, i.e.

$$\frac{Ml}{L}g = \frac{\pi M(L-l)}{L}g$$

or $l = \mu(L - l)$

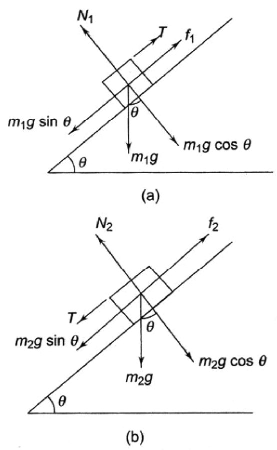
or $l = \dfrac{\mu L}{1+\mu}$

$$\frac{l}{L} = \frac{\mu}{1+\mu} = \frac{0.25}{1+0.25} = \frac{1}{5} \text{ or } 20\%.$$

Hence the correct choices are (a) and (c).

3. **a) the acceleration of the blocks is g(sin θ – μ cos θ).**

c) the tension in the string is zero.



figures (a) and (b) show the free body diagram of the two blocks.

T is the tension in the string and f_1 and f_2 are the frictional forces. If follows from the diagrams that

$N_1 = m_1g \cos\theta$ and $f_1 = \mu m_1 g\cos\theta$

$N_2 = m_2g\cos\theta$ and $f_2 = \mu m_2 g\cos\theta$

If a is the acceleration of the blocks down the plane, the equations of motion are

$m_1a = m_1g\sin\theta - T - f_1$

$= m_1g\sin\theta - T - \mu m_1 g\cos\theta$... (i)

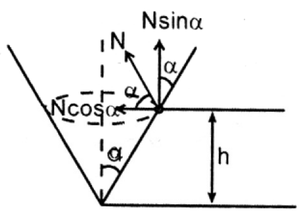
and $m_2a = m_2g\sin\theta + T - f_2$

$= m_2g\sin\theta + T - \mu m_2g\cos\theta$... (ii)

4. **a) increases as h increases**
   c) increases as α increases

As $N\sin\alpha = mg$

$N\cos\alpha = m\omega^2 r$



$\tan\alpha = \frac{g}{\omega^2 r}$ $\therefore T^2 \propto \tan\alpha$

$\therefore$ when a increases T also increases

Also $T^2 \propto r\tan\alpha$

but $r = h\tan\alpha$

$\therefore T^2 \propto h\tan^2\alpha$

for constant α

$T^2 \propto h$

Thus when h increases T also increases

5. **a)** 0.5 sec. if $\omega_1 = \frac{5\pi}{6}$ rad/s and $v_2 = 3.14$ m/s

   d) A can not catch B within 0.5 s, if $\omega_1 = \frac{\pi}{6}$ rad/s and $v_2 = 60.28$ m/s

For case : $\omega_1 = \frac{5\pi}{6}$ rad/sec.

$\omega_{A/T} = \frac{5\pi}{6}$ rad/sec.

$\omega_{B/G} = \frac{v}{R} = \frac{3.14}{3} = \frac{\pi}{3}$ rad/sec.

$\omega_{T/G} = -\frac{\pi}{6}$ rad/sec (in opposite direction)

$\omega_{A/G} = \omega_{A/T} + \omega_{T/G} = \frac{5\pi}{6} + \left(-\frac{\pi}{6}\right)$

$= \frac{4\pi}{6} = \frac{2\pi}{3}$ rad/s.

$\omega_{A/B} = \omega_A - \omega_B = \frac{2\pi}{3} - \frac{\pi}{3} = \frac{\pi}{3}$ rad/sec.

and $\theta_{A/B} = 30^o = \frac{\pi}{6}$ rad/sec.

Using ; $\theta_{rel} = \omega_{i(rel)}t + \frac{1}{2}\alpha_{rel}t^2$

$\frac{\pi}{6} = \frac{\pi}{3}t + 0$

$\Rightarrow t = 0.5$ sec.

6. **b) 37 kg**
   d) 85 kg

For system remain in equilibrium, value of m can be decided in two limiting cases :

Case-I : m can take a maximum value such that 100 kg block has tendency to move upward.

$mg = 100 \times g \times \sin 37^o + \mu \times 100 \times g \times \cos 37^o$

$m = 100 \times \frac{3}{5} + \frac{3}{5} \times 100 \times \frac{4}{5} = 60 + 24 = 84$

Case-II : m can take a minimum value such that 100 kg block has tendency to move downward.

$100 \times g \times \cos 37^o$

$= mg + \mu \times 100 \times g \times \cos 37^o$

$\Rightarrow m = 36$

so we got the range of m

$36 < m < 84$

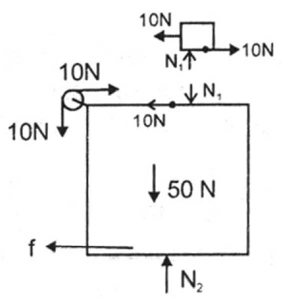
In this range 37 and 83 lie.

7. **a) The normal reaction exerted by the ground on the block B is 110N**
   d) the frictional force exerted by the ground on the block B is zero.

The frictional force on block A is

$\Rightarrow \mu N_1 = 10 \Rightarrow N_1 = \frac{10}{0.2} = 50$ N

The net force on block B in vertical direction is zero



$\therefore N_2 = 50 + N_1 + 10 = 110$ N

$\Rightarrow$ Normal reaction exerted by ground on block B is 110 N.

The net force on block B in horizontal direction is zero

$\therefore f + 10 - 10 = 0$

$\Rightarrow$ frictional force exerted by ground on block B is zero.

8. **a) Tension in the string connecting P_1, P_3 and P_4 is zero**

c) Tension in all the 3 strings is same and equal to zero.

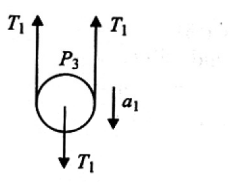
First of all draw FBD of P_3. Let the tension in three strings be T_1, T_2 and T_3, respectively.

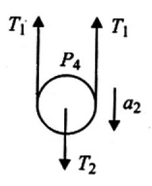
$2T_1 - T_1 = 0 \times a \Rightarrow T_1 = 0$

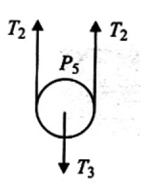
Now draw FBD of P_4 and P_5 (see following figures)

$2T_1 - T_2 = 0 \Rightarrow T_2 = 0$

$2T_2 - T_3 = 0 \Rightarrow T_2 = T_3 = 0$





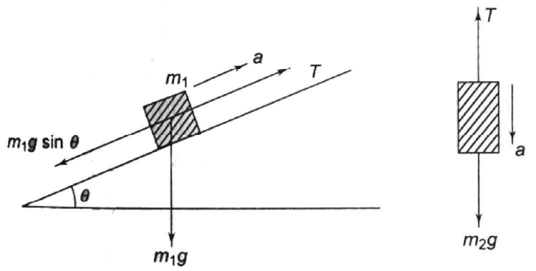


Similarly, for the acceleration draw the FBD of P_6 and P_7 and get the values of acceleratio.

SECTION II - PARAGRAPH TYPE

9. **c)** $\frac{g}{2}$

Since the inclined plane is smooth and $m_2 > m_1$, block m_1 will up the plane and block m_2 will move vertically with a common acceleration a. If T is the tension in the string, the free-body diagrams of masses m_1 and m_2 are as shown in figure



The equations of motion of the blocks are

$T - m_1 g \sin\theta = m_1 a$ (i)

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

Equations (i) and (ii) give

$$a = \frac{(m_2 - m_1 \sin\theta)g}{(m_1 + m_2)} = \frac{(2m - m \times \sin 30^0)g}{(m + 2m)}$$

$$= \frac{g}{2}$$

Hence the correct choice is (c).

10. **a) mg**

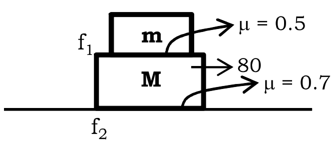
From Eqs. (i) and (ii) we get

$$T = m_2(g - a) = 2m \times \left(g - \frac{g}{2}\right) = mg$$

Hence the correct choice is (a).

SECTION III - MATRIX MATCH TYPE

1.



$f_{2max} = 0.7\ (80) = 56$ N

$f_{1max} = 0.5 \times 30 = 15$ N

$f_{net} = (m + M)\ a$

a= $\frac{24}{8}$ = 3 m/s ²

Required force for smaller block to move together

$f_{required}$ = 3 (3) = 9 N < f_{max}

∴ They move together with acceleration 3 m/s ²

f_1 = 9N

if F = 32, the blocks won't more as

f_{max} = 56 N

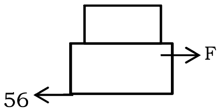
f_{1max} = 15 N, f = ma ; 15 = 3a a = 5 m/s² max

f_{net} = (8) (5) = 40

f_{net} = F – 56

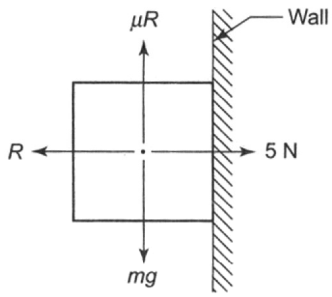
40 = F – 56

F = 96 N



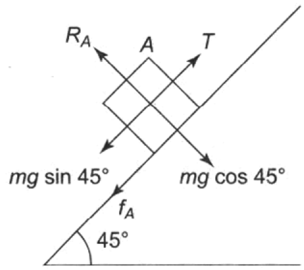
SECTION IV - INTEGER TYPE

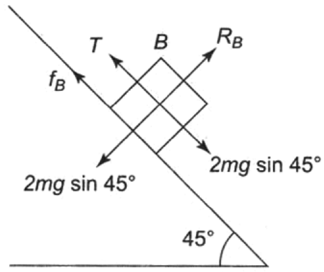
1. Normal reaction R = 5 N.
At equilibrium, the force of friction = weight of the block.



= mg = 0.2 × 10 = 2N

2. Case (a) : Let us assume that block A moves up the plane and block B moves down the plane. The free body diagrams of the blocks are as follows.





The equations of motion of blocks A and B are
T – mg sin 45⁰ – μ_A mg cos 45⁰ = ma, where
μ_A = 2/3 and 2 mg sin 45 – μ_B 2 mg cos 45 – T = 2 ma, where μ_B = 1/3.
Adding these equations and solving we get

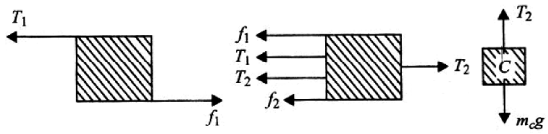
a = $-\frac{g}{9\sqrt{2}}$

Case (b) : If we assume that block A moves down and block B moves up, we would get

a = $-\frac{7g}{9\sqrt{2}}$.

Thus in both cases, the acceleration has a negative value which implies that the blocks will decelerate. This is not possible because the blocks start from rest. Hence when the blocks are released, they move with zero acceleration. Thus acceleration of block A = 0

3. **(2)**
The maximum friction that can be obtained between A and B is
$f_1 = \mu m_A g$ = (0.4)(100)(10) = 400 N.
And the maximum friction between B and the ground is
$f_2 = \mu(m_A + m_B)g$ = (0.4)(100 + 200)(10)
= 1200 N
Drawing free body diagrams of A, B, and C in limiting case, we get



Equilibrium of A gives

$T_1 = f_1 = 400$ N ... (i)

Equilibrium of B gives

$2T_1 + f_1 + f_2 = T_2$

or $T_2 = 2(400) + 400 + 1200 = 2000$ N ... (ii)

Equilibrium of C gives $m_cg = T_2$

or $10m_c = 2000$ or $m_c = 200$ kg $= 2 \times 10^2$ kg.

4. **(8)**

$g \sin \theta = 10 \sin 37^o = 6$ m/sec²

and $\mu g \cos \theta = (0.5)(10) \cos 37^o = 4$ m/sec²

Therefore, minimum acceleration down the plane is

$a = 6 - 4 = 2$ m/sec²

Therefore, minimum speed while reaching the bottom is

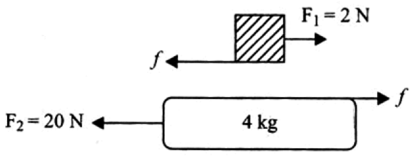
$v^2 = u^2 + 2as = (6)^2 + 2(2)(7) = 64$

$v = 8$ m/sec

5. **(8)**

A free body diagram of the two bodies is as follows.

Let acceleration of both the blocks towards left be a. Then



$a = \dfrac{f-2}{2} = \dfrac{20-f}{4}$

or $2f - 4 = 20 - f$ or $f = 8$ N.

Maximum friction between the blocks is

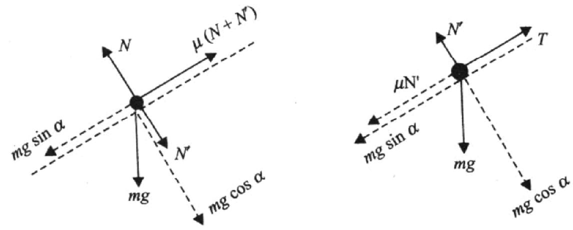
$f_{max} = \mu mg (m = 2 \text{ kg})$

$= (0.5)(2)(10) = 10$ N

Since $f < f_{max}$, the frictional force between the blocks is 8 N.

6. **(4)**

Since A tends to slip down, frictional forces act on it from both sides up the plane.



Let N be the reaction of the plane on A and N′ be the mutual normal action-reaction between A and B. From the free body diagram of A, we get $N' + mg \cos \alpha = N$ and $mg \sin \alpha = (N + N')$ From the free body diagram of B, we get $N' = mg \cos a \Rightarrow mg \sin \alpha + \mu N' = T$

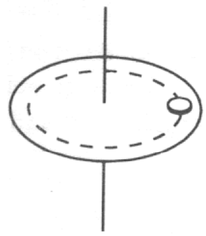
$2mg \cos \alpha = N$

And $mg \sin \alpha = (2mg \cos \alpha + mg \cos \alpha)$

$$= \frac{1}{3} \tan \alpha$$

$$= \frac{1}{3} \tan 37^o = \frac{1}{3} \times \frac{3}{4} = 0.25 = \frac{1}{4}$$

7. **5)**



The friction force on coin just before coin is to slip will be : $f = \mu_s mg$

Normal reaction on the coin; $N = mg$

The resultant reaction by disk to the coin is

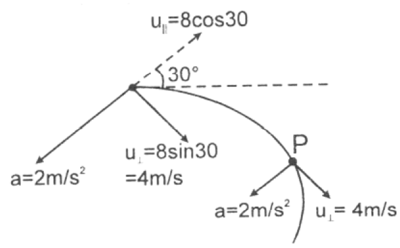
$= \sqrt{N^2 + f^2} = \sqrt{(mg)^2 + (\mu_s mg)^2}$

$= mg\sqrt{1 + \mu_s^2}$

$= 40 \times 10^{-3} \times 10 \times \sqrt{1 + \dfrac{9}{16}} = 0.5$ N

8. **8)**

The acceleration vector shall change the component of velocity u_{II} along the acceleration vector.



PART B - CHEMISTRY

SECTION I - MULTIPLE ANSWER CORRECT TYPE

1. **a) Mole ratio of $Na_2C_2O_4$ and $H_2C_2O_4$ = 4 : 1**
   b) Equivalent ratio of Na_2C_2O and $H_2C_2O_4$ = 4 : 1
   c) Moles of $C_2O_4^{2-}$ in mixture = 25×10^{-3}

   Meq. of $KMnO_4 = 100 \times 0.1 \times 5 = 50$

   Meq. of $Na_2C_2O_4$ + Meq. of $H_2C_2O_4$

   $a \quad + \quad b$

   $\therefore \quad a + b = 50$

   Meq. of NaOH = $50 \times 0.2 = 10$ = Meq of $H_2C_2O_4$

   $\therefore \quad b = 10$

   $\therefore \quad a = 40$

   m moles of $Na_2C_2O_4 = \frac{a}{2}$

   m mole of $C_2O_4 = \frac{a}{2} + \frac{b}{2} = \frac{a+b}{2} = \frac{40+10}{2} = 25$

   m moles of $H_2C_2O_4 = \frac{b}{2}$

2. **a) In H_2SO_4**

   HNO_3 also oxidises Fe^{2+} whereas $KMnO_4$ oxidises HCl.

3. **a) 3 electrons in neutral medium**
   c) 3 electrons in alkaline medium
   d) 5 electrons in acidic medium

   In acidic medium : $Mn^{7+} + 5e \longrightarrow Mn^{2+}$

   In neutral medium : $Mn^{7+} + 3e \longrightarrow Mn^{4+}$

   In alkaline solution : $Mn^{7+} + e \longrightarrow Mn^{6+}$

   Note that in alkaline medium, Mn^{6+} is further reduced to Mn^{4+}

   $Mn^{6+} + 2e \longrightarrow Mn^{4+}$

   Thus over all reaction may give

   $Mn^{7+} + 3e \longrightarrow Mn^{4+}$

4. **a) $2Rb + 2\,H_2O \rightarrow 2\,RbOH + H_2$**
   b) $2\,CuI_2 \rightarrow 2\,CuI + I_2$

   Reactions

   i) $2\overset{0}{Rb} + 2\overset{+1}{H_2}O \longrightarrow 2\overset{+1}{Rb}OH + \overset{0}{H_2}$

   ii) $2\overset{+2-1}{CuI_2} \longrightarrow 2\overset{+1}{C}uI + \overset{0}{I_2}$ involve oxidation reduction.

5. **a) $2\,Cu^+ \rightarrow Cu^{2+} + Cu$**
   b) $3\,Cl_2 + 6\,OH^- \rightarrow ClO_3^- + 5\,Cl^- + 3\,H_2O$
   c) $2\,H_2O_2 \rightarrow 2\,H_2O + O_2$
   d) $3I_2 \rightarrow 5I^- + I^{5+}$

   All these three represent disproportionation reactions.

6. **a) $S_2O_3^{2-}$ gets oxidised to $S_4O_6^{2-}$**
   c) I_2 gets reduced to I^-

   Here, $S_2O_3^{2-}$ gets oxidised to $S_4O_6^{2-}$ while I_2 is reduced to I^- ions.

7. **a) HNO_2**
   b) SO_2
   c) H_2O_2

   HNO_2, SO_2 and H_2O_2 act both as oxidising as well as reducing agents.

8. **a) 0.5 M Fe^{2+}**
   b) 0.25 M $C_2O_4^{2-}$
   c) 0.25 M H_2O_2
   d) 0.5 M I^-

   All option are correct.

SECTION II - PARAGRAPH TYPE

9. **b) M**

$$2e + (C^{3+})_2 \longrightarrow 2C^{2+}$$
$$(C^{3+})_2 \longrightarrow 2C^{4+} + 2e$$
$$\overline{(C^{3+})_2 \longrightarrow 2C^{2+} + 2C^{4+}}$$

$$2(CN)_2 + 2H_2O \longrightarrow 2HCN + 2HOCN$$

2 mol $(CN)_2$ = 2 mole HCN

= 2 × leq. HCN (V. f for HCN = 1)

2 eq. $(CN)_2$

$\therefore$ 1 mole of $(CN)_2$ = 1 eq. $(CN)_2$

or V.f. for $(CN)_2$ = 1

$\therefore$ E = M

10. **a) $\frac{M}{6}$**

$$6e + Cl^{5+} \longrightarrow C^{-1}$$
$$2\left(O^{-2}\right)_3 \longrightarrow 3\left(O_2^0\right) + 12e$$
$$\therefore\ 2KClO_3 \longrightarrow 2KCl + 3O_2$$

2 mole $KClO_3 \equiv$ 2 mole KCl

$\equiv 2 \times 6$ eq. KCl

$\equiv 12$ eq. $KClO_3$

$\therefore$ 1 mole $KClO_3 \equiv 6$ eq. $KClO_3$

$\therefore$ V.F. for $KClO_3 \equiv 6$

$\therefore\ E_{KClO_3} = \frac{M}{6}$

SECTION III - MATRIX MATCH TYPE

1. A-Q ; B-R ; C-P ; D-S

SECTION IV - INTEGER TYPE

1. 3

n-factor for $K_2Cr_2O_7 = 6$

$\therefore\ 1.68 \times 10^{-3} \times 6 = 3.26 \times 10^{-3} \times n$

$\therefore\ n = 3$

2. 2

3. 5

Volume strength of $H_2O_2 = N \times 5.6$

as $N_1V_1 = N_2V_2$

$$\frac{1}{24} \times 80 \times 6 = N_{H_2O_2} \times 22.4$$

$$N_{H_2O_2} = \frac{20}{22.4}$$

$$\therefore\ \text{V.S. of } H_2O_2 = \frac{20}{22.4} \times 5.6 = 5$$

4. 6

5. 6

$$K_2Cr_2O_7 + H_2SO_4 + 3\,SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$$

In this reaction, $\overset{+4}{S}O_2$ is oxidised to $\overset{+6}{S}O_4^{2-}$ ion and the oxidation state of S is changed from + 4 in So_2 to + 6 in SO_4^{2-} ion.

6. 7

$$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10\,CO_2 + 8\,H_2O$$

As 2 moles of MnO_4^- oxidises 5 moles of $C_2O_4^{2-}$

So, 1 mole of MnO_4^- will oxidise 5/2 moles of $C_2O_4^{2-}$

i.e., $x = 5$ and $y = 2$ $\therefore\ x + y = 5 + 2 = 7$

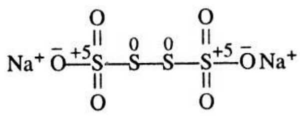
7. 5

$$2\,MnO_4^- + 10\,I^- + 16\,H^+ \longrightarrow 2Mn^{2+} + 5\,I^2 + 8\,H_2O$$

In the above reaction, MnO_4^- has Mn in + 7 O.S. and in the product Mn is in + 2 O.S. thus, the reaction involves the transfer of 5 electrons.

8. 5

Struture of $Na_2S_4O_6$ is



The oxidation state of each of the terminal sulphur atoms is +5 and each of the two central sulphur atom is zero. Thus, the difference in oxidation numbers of two types of S atoms is 5 – 0 = 5.