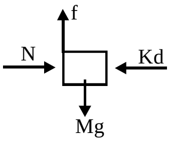
5.



N = Kd

f = Mg

$f \le \mu_s N$

$Mg \le \mu_s Kd$

$K \ge \dfrac{Mg}{\mu_s d}$

6. x = μcosθt $\qquad$ $y = \mu\sin\theta t - \dfrac{1}{2}gt^2$

x = 36t $\qquad$ $y = \dfrac{96}{2}t - \dfrac{1}{2}(9.8)t^2$

μcosθ = 36

$\mu\sin\theta = \dfrac{96}{2}$

$\therefore \tan\theta = \dfrac{96/2}{36} = \dfrac{4}{3}$

$\therefore \sin\theta = \dfrac{4}{5}$

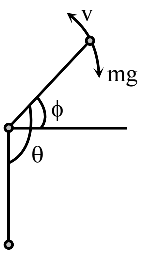
11. (B) 10 × 1 – 2 × 2 = 12 V

∴ v = 0.5 m/s

(D) Loss = $\dfrac{1}{2}\times 10\times 1^2 + \dfrac{1}{2}\times 2\times 2^2 - \dfrac{1}{2}\times(12)\times 0.5^2$

= 9 – 1.5 = 7.5J

12.



$Mg\sin\phi = \dfrac{mv^2}{l}$

$v^2 = lg\sin\phi$

$\dfrac{1}{2}m\dfrac{7gl}{2} = \dfrac{1}{2}mv^2 + mg(l + l\sin\phi)$

$\sin\phi = \dfrac{1}{2}, \quad \phi = 30^\circ$

Total angle (θ) = 90 + 30 = 120º

13. $\vec{a}_c = \dfrac{v^2}{r}\left(-\cos\theta\,\hat{i} - \sin\theta\,\hat{j}\right)$

$= \dfrac{2^2}{4}\left(-\cos 45\hat{i} - \sin 45\hat{j}\right)$

$= -\left(\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

14. For eq. of person f = mg

μN = mg

$\mu m r\omega^2 = mg$

so, $\omega_{min} = \sqrt{\dfrac{g}{\mu r}} = \sqrt{\dfrac{10}{0.2\times 2}} = \sqrt{25} = 5$ rad / sec

16. $\vec{F_C} = -\left[\dfrac{\partial U}{\partial x}\hat{i} + \dfrac{\partial U}{\partial y}\hat{j} + \dfrac{\partial U}{\partial z}\hat{k}\right]$

Put $U = \dfrac{20yz}{x}$

$\vec{F_C} = \left(\dfrac{20yz}{x^2}\right)\hat{i} - \left(\dfrac{20z}{x}\right)\hat{j} - \left(\dfrac{20y}{x}\right)\hat{k}$

19. $y = x\tan\theta - \dfrac{1}{2}g\dfrac{x^2}{u^2\cos^2\theta}$

$y = x\,.\,1 - \dfrac{1}{2}\,.\,\dfrac{x^2}{1}$

∴ tan θ = 1 $\quad$ θ = 45°

$\dfrac{u^2\cos^2\theta}{g} = 1$

$u = \dfrac{\sqrt{g}}{\cos\theta} = \sqrt{2g}$

$T = \dfrac{2u\sin\theta}{g} = \dfrac{2\sqrt{2g}\dfrac{1}{\sqrt{2}}}{g} = \dfrac{2}{\sqrt{g}}$

20. $a = u_1\cos 30\, t = u_2\cos 60\, t$

& $y = u_2\sin 60\, t - (1/2)\,gt^2$

& $-(h - y) = u_1\sin 30\, t - (1/2)gt^2$

$\Rightarrow$ $y = a\tan 60 - (1/2)gt^2$

$\Rightarrow$ $y - h = a\tan 30 - (1/2)gt^2$

$\therefore$ h = a (tan60 – tan30) $\Rightarrow h = 2a/\sqrt{3}$

SECTION-II

1. $r = \dfrac{100}{\sqrt{19}}$ m

at 2 sec, $\qquad v = 2\times 2^2 + 2 = 10$ m/s

$v = 2t^2 + t$

$$a_{cp} = \frac{v^2}{r} = \frac{100}{100/\sqrt{19}} = \sqrt{19}\ \ m/s^2$$

$$a_t = \frac{dv}{dt} = ut + 1$$

at t = 2 sec

$$a_t = 9\ \ m/s^2$$

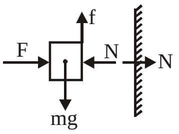
then, $a_{net} = \sqrt{a_{cp}^2 + a_t^2}$

$$a_{net} = \sqrt{\left(\sqrt{19}\right)^2 + 9^2} = 10\ \ m/s^2$$

2. Given,
$r = 500$ m, $v = 30$ m/s, $a_t = 2$ m/s^2

$$a_r = \frac{v^2}{r} = \frac{900}{500} = \frac{9}{5}$$

$$\therefore \quad a = \sqrt{a_r^2 + a_t^2} = \sqrt{\frac{81}{25} + 4} \simeq 2.7\ m/s^2$$

3. 

$f = \mu N$

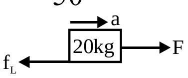
$N = F$

$f = 0.2 \times 9.8$

$mg = f = 1.96$ N

7. time of flight = (5 sec) × 2 = 10 sec
$\mu = gt = 9.8 \times 5 = 49$ m/s

8. $a = \dfrac{F}{50}$, $f_L = (0.4)(200) = 80$ N



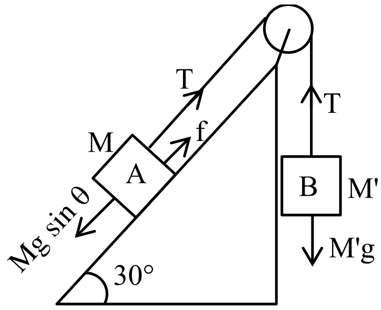
$F - 80 = 20a$

$$F - 80 = 20\left(\frac{F}{50}\right)$$

$$\frac{3F}{5} = 80$$

$$F = \frac{400}{3}\ N$$

9. Mass moving by constant velocity
so, $Mg\sin\theta = T + f$



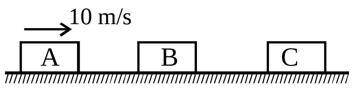
$Mg\sin\theta = T + f$

$f = \mu mg\cos\theta$

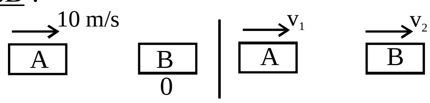
$$\frac{Mg}{2} = T + \mu Mg \times \frac{\sqrt{3}}{2} \qquad ..(i)$$

$T = M'g \qquad \ldots(ii)$

$$M' = \frac{M}{3}$$

10. 

A&B :

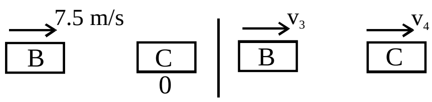


$10 = v_1 + v_2 \qquad ....(1)$

$$e = \frac{v_2 - v_1}{10} = 0.5 \Rightarrow v_2 - v_1 = 5 \qquad ....(2)$$

$\therefore\ v_2 = 7.5$ m/s

B&C :



$7.5 = v_3 + v_4 \qquad ...(1)$

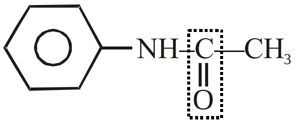
$$e = \frac{v_1 - v_3}{7.5} = 0.5$$

$v_4 - v_3 = 3.75 \qquad ...(2)$

$2v_4 = 11.25 \Rightarrow v_4 = 5.6$ m/s

PART-2 CHEMISTRY
SECTION-I

12. $[Ni(CO)_4] \xrightarrow{\Delta} Ni + 4CO$

13. 

Principal Fn. Group $-\underset{\displaystyle \|\atop O}{C}-NH_2$ (amide)

N-Phenylethanamide.

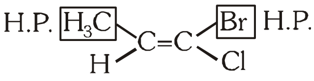
14.

$CH_3-CH_2-\overset{\overset{\displaystyle CH_3}{|}}{C}H-CH=O$ $\quad C_5H_{10}O$

$CH_3-\underset{\underset{\displaystyle O}{\|}}{C}-O-CH_2-CH_2-CH_3$ $\quad C_5H_{10}O_2$

$CH_3-CH_2-CH_2-CH_2-CH=O$ $\quad C_5H_{10}O$

In (I and III)
→ Size of parent chain differ
→ Chain isomer

15. 

Z–

H.P. : Higher priority according to CIP rule

H.P. — Same side ⟶ Z
H.P. — Opposite side ⟶ E

SECTION-II

3. $T = \dfrac{\Delta H_{vap}}{\Delta S_{vap}} = \dfrac{30\times10^3}{75} = 400K$

5. Haemetite – Fe_2O_3

Chromite – $FeO . Cr_2O_3$

Limonite – $Fe_2O_3 . 2H_2O$

Magnetite – Fe_3O_4

Siderite – $FeCO_3$

Iron pyrites – FeS_2

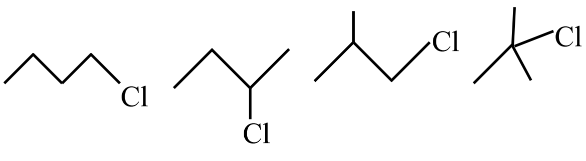
6. Azurite – $2CuCO_3 . Cu(OH)_2$

Malachite – $CuCO_3 . Cu(OH)_2$

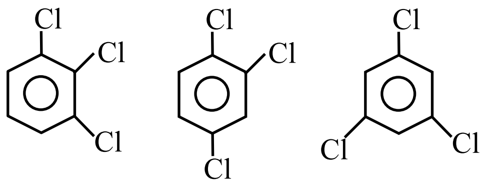
Cuprite – Cu_2O

Chalcocite – Cu_2S

7. For unsymmetrical
No. of G.I. = $2^n = 2^3 = 8$

8. 

(1) (2) (3) (4)

9. 

PART-3 MATHEMATICS
SECTION-I

3. $I = \int_0^{2\pi} \dfrac{x\sin^{2n}x}{\sin^{2n}x+\cos^{2n}x}dx$ ......(1)

$= \int_0^{2\pi} \dfrac{(2\pi-x)\sin^{2n}(2\pi-x)}{\sin^{2n}(2\pi-x)+\cos^{2n}(2\pi-x)}dx$ [by P–4]

$= \int_0^{2\pi} \dfrac{(2\pi-x)\sin^{2n}x}{\sin^{2n}x+\cos^{2n}x}dx$ ......(2)

$\therefore\ 2I = 2\pi\int_0^{2\pi} \dfrac{\sin^{2n}x}{\sin^{2n}x+\cos^{2n}x}dx$

$\Rightarrow\ I = 4\pi\int_0^{\pi/2} \dfrac{\sin^{2n}x}{\sin^{2n}x+\cos^{2n}x}dx$ [By Property 6]

$= 4\pi(\pi/4) = \pi^2$

4. $I_k = \int_1^e (\ell nx)^k dx$

$I_4 = \int_1^e (\ell nx)^4 dx = (\ell nx)^4.x - \int 4(\ell nx)^3.\dfrac{1}{x}.xdx$

$= x(\ell nx)^4 - 4\left[(\ell nx)^3.x - \int 3(\ell nx)^2 dx\right]$

$= x(\ell nx)^4 - 4x(\ell nx)^3 + 12\left[(\ell nx)^2.x - \int 2\,\ell nx\,dx\right]$

$= \left[x(\ell nx)^4 - 4x(\ell nx)^3 + 12x(\ell nx)^2 - 24(x\ell nx - x)\right]_1^e$

= (e – 4e + 12e – 24e + 24e) – 24

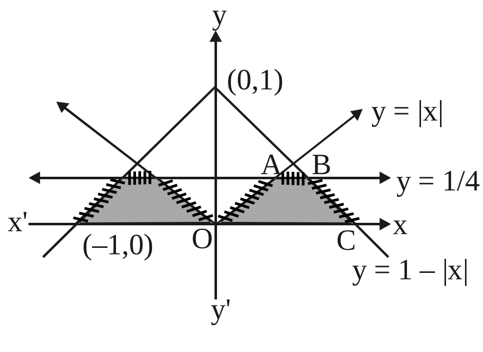
$\Rightarrow$ $\boxed{9e-24}$

5. $\sqrt{x} = 0, 1, 2, 3, ...$

x = 0, 1, 4

$\int_0^1 0\,dx + \int_1^3 1\,dx$

6. $f(x) = \min\left(|x|, 1-|x|, \dfrac{1}{4}\right)$



Now, from figure, we have

$\int_{-1}^{1} f(x)dx = 2$ (Area of trapezium OABC)

$= 2\left(\frac{1}{2}\left(1+\frac{1}{2}\right)\frac{1}{4}\right) = \frac{3}{8}$

7. $I = \int_{-1}^{1} x\,dx - \int_{-1}^{1}[2x]dx$

$= \left(\frac{x^2}{2}\right)_{-1}^{1} - \left\{\int_{-1}^{-1/2}[2x]dx + \int_{-1/2}^{0}[2x]dx + \int_{0}^{1/2}[2x]dx + \int_{1/2}^{1}[2x]dx\right\}$

$= 0 - \left\{\int_{-1}^{-1/2}(-2)\,dx + \int_{-1/2}^{0}(-1)\,dx + \int_{0}^{1/2}0\,dx + \int_{1/2}^{1}1\,dx\right\}$

$= 1$

8. In R, put x = 2t or dx = 2dt

$\therefore$ $R = 2\int_{0}^{1/2} 2^{50}\, t^{50}\, 2^{50}(1-t)^{50}\,dt$ ……(i)

Now, $K = 2\int_{0}^{1/2} x^{50}(1-x)^{50}\,dt$ ……(ii)

From (i) & (ii),

$R = 2^{100} K$

9. $I = \int_{-\pi/2}^{\pi/2}(\sin^2 x - \sin^4 x)\ (\sin x - \cos x)dx$

$= I_1 + I_2$, where

$I_1 = \int_{-\pi/2}^{\pi/2}(\sin^3 x - \sin^5 x)dx = 0$

$[\because f(-x) = -f(x)]$

$I_2 = \int_{-\pi/2}^{\pi/2}(\sin^4 x - \sin^2 x)\cos x\,dx$

$= 2\int_0^1 (t^4 - t^2)dt$ $[\because f(-x) = f(x)$ and $\sin x = t]$

$= 2\left[\frac{1}{5} - \frac{1}{3}\right] = -\frac{4}{15}$

I = 0 – 4/15 = –4/15

10. $S = \lim_{n\to\infty}\left\{\frac{1}{(n+1)(n+2)} + \frac{1}{(n+2)(n+4)} + \ldots + \frac{1}{(n+n)(n+2n)}\right\}$

$= \lim_{n\to\infty}\sum_{r=1}^{n}\frac{n^2}{(n+r)(n+2r)}\cdot\frac{1}{n}$

$= \lim_{n\to\infty}\sum_{r=1}^{n}\frac{1}{\left(1+\frac{r}{n}\right)\left(1+\frac{2r}{n}\right)}\cdot\frac{1}{n}\ \frac{r}{n}\to x, \frac{1}{n}\to dx$

$a = \lim_{n\to\infty}(r/n)_{r=1} = 0$; $b = \lim\left(\frac{r}{n}\right)_{r=n} = 1$

$\Rightarrow S = \int_0^1 \frac{dx}{(1+x)(1+2x)} = \int_0^1\left(\frac{2}{1+2x} - \frac{1}{1+x}\right)dx$

$= \left[\log(1+2x) - \log(1+x)\right]_0^1 = \log(3/2)$

11. $f(x) = \frac{4^{x+1}}{4^{x+1}+8} = \frac{4^x}{4^x+2}$

$f(1-x) = \frac{4^{1-x}}{4^{1-x}+2} = \frac{2}{4^x+2}$

$\therefore$ $f(x) + f(1-x) = 1 \Rightarrow f(\sin^2 5) + f(\cos^2 5) = 1$

$a = \int_{f(\sin^2 5)}^{f(\cos^2 5)} 4f(u(1-u))du$

$a = \int_{f(\sin^2 5)}^{f(\cos^2 5)} (1-u)f((1-u)u)du = b - a$

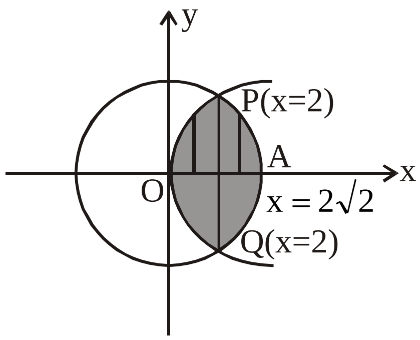
$\Rightarrow 2a = b \Rightarrow a/b = 1/2$

12. Put $x^2 = z$, then $\int_1^4 \frac{2e^{\sin x^2}}{x}dx = \int_1^{16}\frac{e^{\sin z}}{z}dz$

$= \int_1^{16}\frac{d}{dz}[F(z)dz = \left[F(z)\right]_1^{16} = F(16) - F(1)$

$\therefore$ K = 16

13. Two curves meet at P and Q where x = 2. Obviously the required area lies between x = 0 and x = $2\sqrt{2}$. It is symmetrical about x-axis and bounded by two given curves. So required area



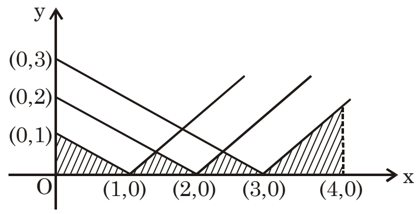
$$= 2\left[\int_0^2 \sqrt{2}\sqrt{x}\,dx + \int_2^{2\sqrt{2}} \sqrt{8-x^2}\,dx\right]$$

$$= 2\left[\left(\frac{2\sqrt{2}}{3}x^{3/2}\right)_0^2 + \left(\frac{x}{2}\sqrt{8-x^2} + 4\sin^{-1}\frac{x}{2\sqrt{2}}\right)_2^{2\sqrt{2}}\right]$$

$$= 2\left[\left(\frac{8}{3}-0\right) + (2\pi - 2 - \pi)\right] = 2\pi + 4/3.$$

SECTION-II

1.



Required value

$$= \frac{1}{2}(1)(1) + 2\left(\frac{1}{2}\times 1\times\frac{1}{2}\right) + \frac{1}{2}\times 1\times 1 = \frac{3}{2}$$

5. $\int_0^2 x f(x)\,dx = f(x).\frac{x^2}{2}\Big|_0^2 - \int_0^2 f'(x).\frac{x^2}{2}\,dx = 2$

6. $I_1 = \int_0^1 \cot^{-1}(1 - x + x^2)\,dx = \int_0^1 \tan^{-1}\frac{x-(x-1)}{1+x(x-1)}\,dx$

$$= \int_0^1 \tan^{-1}x\,dx - \int_0^1 \tan^{-1}(x-1)\,dx$$

$$= \int_0^1 \tan^{-1}x\,dx - \int_0^1 \tan^{-1}(1-x-1)\,dx$$

$$= \int_0^1 \tan^{-1}x\,dx + \int_0^1 \tan^{-1}x\,dx = 2\int_0^1 \tan^{-1}x\,dx$$

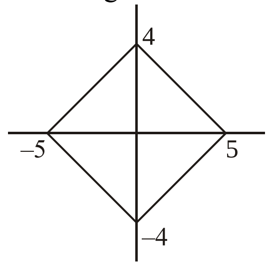
$\Rightarrow I_1 = 2I_2 \quad \therefore I_1/I_2 = 2$

7. $1 \le e^{x^2} \le e^x$ in $(0,1)$

$\therefore \quad 1 \le \int_0^1 e^{x^2}dx \le \int_0^1 e^x = e - 1$

$\therefore \quad 1 \le k \le e - 1 \Rightarrow [k] = 1$

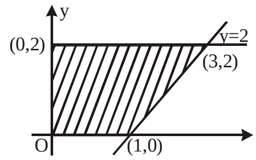
8. Reqd. area is same as area of the region bounded



by $4|x| + 5|y| \le 20$

Reqd. $= 4 \times \frac{1}{2} \times 4 \times 5 = 40$

9. $-8 < x < 8 \Rightarrow y = 2$



$\therefore$ Required area $= \frac{1}{2}(1+3)\times 2$

= 4 sq unit