Q.No. 1. Explain any five in brief with the help of neat sketch:-

a) *Whit worth quick return Mechanism :-*

Ans:-

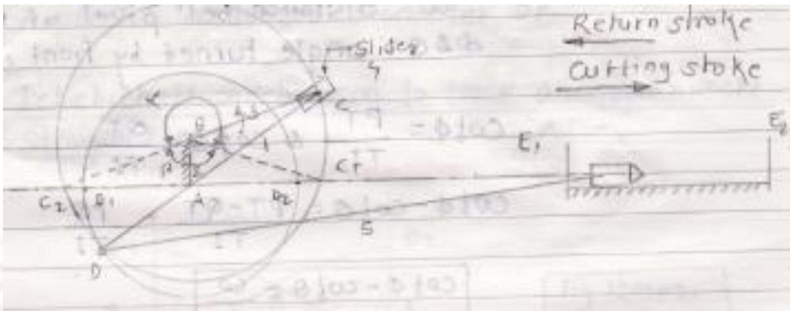


Fig-1.5M,Exp-2.5 M

This mechanism is used in workshops to cut metals. The forward stroke cuts the metal whereas the return stroke is ideal. The FS takes a little longer period where as the RS takes a shorter period Fig. shows this mechanism in which link 2 is fixed. The link 3 along with its slider (i.e. link4) rotates in a circle about B. By doing so, the link 1 rotates about A along with the slider which reciprocates on link 1.On the link 1 produced downward there is a point D where link 5 is connected. The other end of the link5 is connected to tool(link6).The FS of the tool cuts metal whereas the RS is ideal. The point D rotates in a circle about point A.

b) Condition for correct steering :-

Ans:

Let, l=wheel base
w=distance between pivot of front wheel.
Ø&θ=angle turned by front wheel

$$\cot Ø = \frac{PT}{TI}, \cot\theta = \frac{QT}{TI}$$

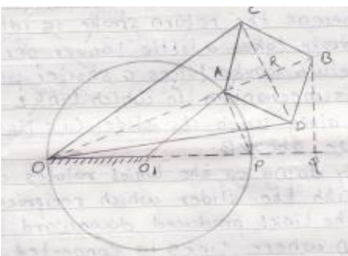
$$\cot Ø - \cot\theta = \frac{PT - QT}{TI} = \frac{PQ}{TI}$$

$$\cot Ø - \cot\theta = \frac{w}{l}$$

Fig-1.5M,Exp-2.5 M

c) Peaucellier Mechanism:-

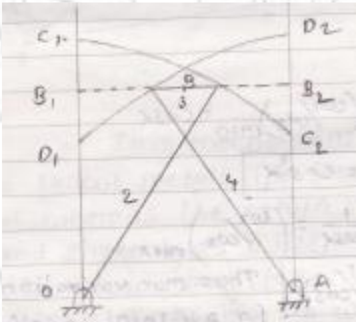
Ans:



It consist of a fixed link OO_1 & the other straight links O1A,OC,OD,AD,BD,BC,AC are connected by turning pairs at their intersections as shown in fig. The pin at A is constrained to move along the circumference of circle with the fixed diameter OP, by means of link O1A in fig.AC=CB=BD=DA, OC=OD,& OO_1=O_1A.Here product OAXOB remains constant. When the link O_1A rotates, join CD to bisect AB at R.Since OC & BC are of constant length therefore he product OBXOA remains constant.
Hence he point B traces a straight path perpendicular to the diameter OP.

Fig-1.5M,Exp-2.5 M

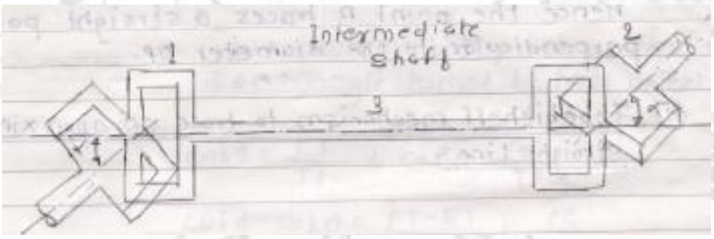
d) Tchebicheff mechanism to trace an approximate straight line:-



It consists of four links namely OC,CD,AD & OA. The link OA is fixed. The links OC & AD are equal & crossed. B is the midpoint of CD. The point B is the tracing point. The proportions of links are such that B,C & D lies on vertical lines when on extreme positions i.e. when directly above O or A. The mean position is shown by ADCO whereas the extreme position above O is shown by AD_1C_1O.All he links should be in the following ratio CD:OA:OC=1:2:2.5 then point B will move in a horizontal straight line parallel to OA. Fig-1.5M,Exp-2.5 M

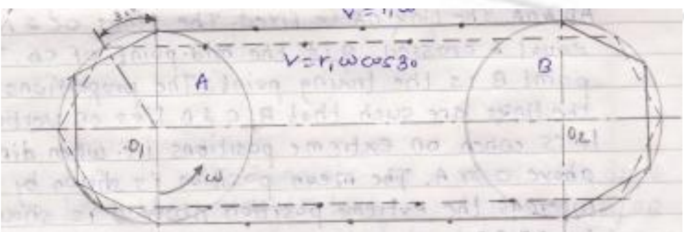
e) Double Hook Joint:-

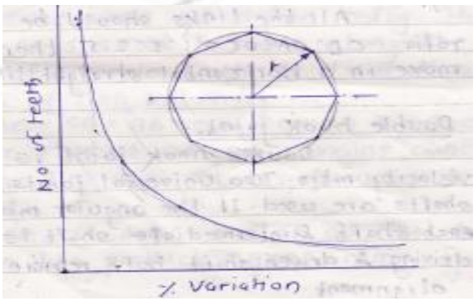
Ans:



Double hook joint is used for constant velocity ratio. Two universal joints & one intermediate shaft are used. If the angular misalignment between each shaft & intermediate shaft is equal, then the driving & driven shaft both remain in exact angular alignment. Fig-1.5M,Exp-2.5 M

f) Chordal action of chain:- Fig-1.5M,Exp-2.5 M

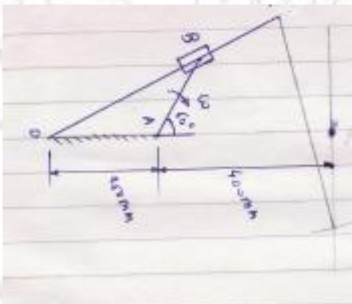


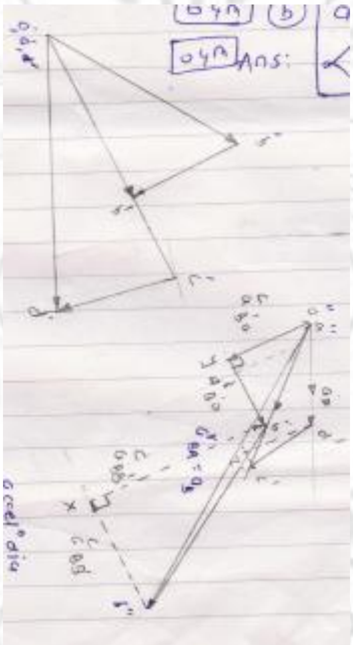


Q.No. 2.(a) For the crank and slotted lever mechanism shown in fig. the dimensions of various links are

OA=250mm
AB=200mm
OC=600mm
CD=500mm
The crank rotates at 60 rpm.
Determine the velocity of slider 'D'& angular velocity of link 'CD'by
i)Relative Velocity Method
ii)I.C.Mehod.

Ans:





i)Relative Velocity Method:

Velocity of slider D V_D=2m/s

Angular Velocity CD

$W_{CD}=V_{CD}/ CD=0.8953/0.5$

$W_{CD}= 1.7905 \text{ rad/s}^2$

ii)ICR Method: V_D=2m/s

$W_{CD}= 1.7905 \text{ rad/s}^2$

b) For the same mechanism, determine the linear acceleration of slider'D' and angular acceleration of link 'CD' by graphical method.

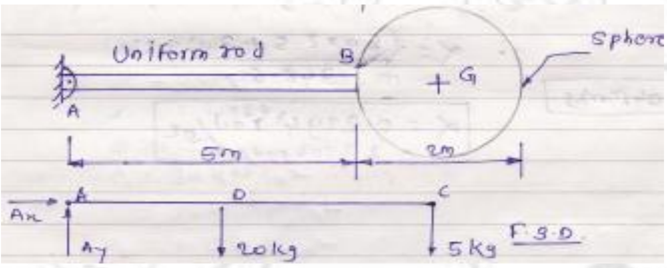
$a_D= 4 \text{m/s}^2$

$\alpha_{CD}=5.5184 \text{ rad/s}^2$

Q.No. 3. a)A composite system consisting of rod 'AB' and a sphere with center 'G'.Fixed rigidly to the rod at 'B' as shown in fig..Determine the angular acceleration of the system at the instant when it is released from the horizontal position. Mass of rod is 20kg and the mass of sphere=5kg,AB=5m and dia. of sphere=2m

Given data,

Mass of rod=m=20kg
Mass of sphere=m=5kg
AB=5m
Dia.of sphere=2m



Let the assembly will rotate at an angular acceleration of α

Mass moment of inertia of bar about A

$I_R = I_G + mK_2$

$= mL_2 + mk_2$

$= \frac{20}{12} X\, 5^2 + 20X2.5^2$

$= 166.67$ kg-m^2

Mass moment of inertia of sphere about A

$= \frac{2}{5} mr^2 + mk^2$

$= \frac{2}{5} x5x1^2 + 5x6^2$

$I_S = 182.00$ kg-m^2

Mass moment of inertia of system,

$I = I_R + I_S$

$= 166.67 + 182$

$I = 348.67$ kg-m^2

Now from body Dia. & kinetic Dia.

Using the equation of equilibrium for rotation

$\sum M_A = -I_A\, \alpha$

$9.81(-20X2.5-5X6) = -346.67X\alpha$

$\boxed{\alpha = 2.2504 \text{ rad/s}^2}$

b) A vertical double acting steam engine has a cylinder 300mm diameter & 450mm stroke & runs at 200rpm.The reciprocating parts has a mass of 225Kg & the piston rod is 50mm diameter. The connecting rod is 1.2m long. When the crank has turned through 125^0 from top dead center, the steam pressure above the piston is 30 kN/m^2 & below the piston is 1.5 kN/m^2 .

Calculate the tangential force on the crank pin and effective turning moment on the crank shaft.

Ans:

D=300=0.3m , L=450mm or r=L/2=225mm=0.225m,

N=200 rpm or w= 2xΠx200/60=20.95 rad/s, m_R=225kg d=50mm=0.05m, l= 1.2m, $\theta=125^0$

$P_1=30x10^3 N/m^2$, $P_2=1.5x10^3 N/m^2$

We know that,

Area of piston,

$A_1= \frac{\pi}{4} D^2$ =0.0707 m^2

Area of the piston rod,

a= $\frac{\pi}{4} d^2$= 0.00196 m^2

Force on the piston due to seam pressure

∴ $F_L=P_1A_1-P_2(A_1-a)=30x10^3x0.0707-1.5x10^3(0.0707-0.00196)$

=2121-103

F_L =2018N

Ratio of length of connecting rod & crank

n=l/r=1.2/0.225=5.33

& inertia force on the reciprocating parts

$F_I = m_R\, w^2 r(\cos\theta + \frac{\cos 2\theta}{n})$

$\therefore F_I = -14172N$

We know that, for a vertical engine, net force on the piston or piston effort

$F_P = F_L - F_I + m_R\, g$ =18397N

Let ø=Angle of inclination of the connecting rod to the line of stroke,

We know that,

$\sin \emptyset = \frac{\sin\theta}{n} = \frac{\sin 125}{5.33}$

$\therefore \emptyset = 8.84^o$

1)Tangential force on he crank pin,

$F_T = \frac{F_P}{\cos\emptyset} \sin(\theta + \emptyset)$ =13429.33N

$\boxed{F_T = 13429.33N}$

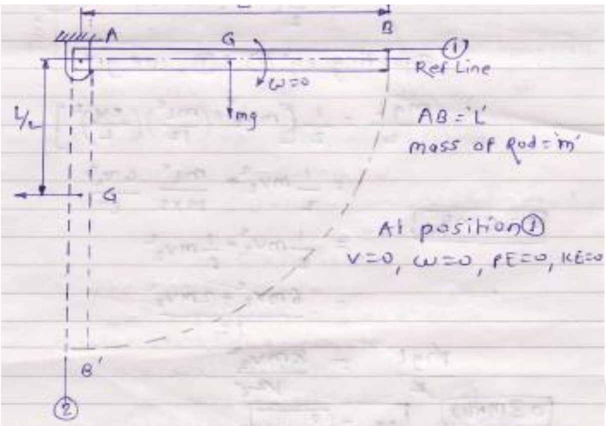
2) Effective turning moment on the crank shaft,

$T=F_T xr=13429.33x0.255$

T=3021.6 N-m

Q.No. 4.a)A uniform bar of mass 'm' and length 'L'hangs from a frictionless hinge.It is released from the horizontal position as shown in fig.

Ans:



$U_{1-2}=(T_2-T_1)$

Work done=change in K.E.

In case of rigid body,

Work done= $\int_{S_1}^{S_2}(F\cos\alpha)\,ds+\int_{\theta_1}^{\theta_2}M\,d\theta$

U_{1-2}=FS+ Mθ $\quad(\because FS=0)$

U_{1-2}= Mθ =$\frac{mgL}{2}$-------------------------------------(i)

Principle of work & energy gives,

$U_{1-2}=(T_2-T_1)$

$=(\frac{1}{2}mV_2^2+\frac{1}{2}Iw_2^2)-(\frac{1}{2}mV_1^2+\frac{1}{2}Iw_1^2)$

$=(\frac{1}{2}mV_2^2+\frac{1}{2}Iw_2^2)-(o)$

$=(\frac{1}{2}mV_2^2+\frac{1}{2}Iw_2^2)$-------------------------------(ii)

Equating equation (i) & (ii),we get, $\frac{mgL}{2}=(\frac{1}{2}mV_2^2+\frac{1}{2}Iw_2^2)$

$$\frac{mgL}{2}=\frac{8}{12}mV_2^2$$

$$\therefore V_2=\sqrt{\frac{3}{4}gl}$$

$$w=\frac{V_2}{L/2}$$

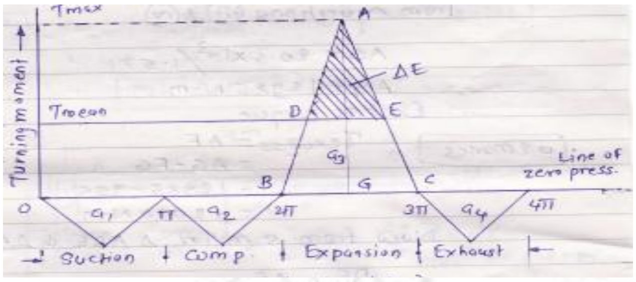
$$\therefore w=\sqrt{3\frac{g}{L}}$$

Q.No. 4.b)The turning moment dia. of a four stroke engine may be assumed for the sake of simplicity to be represented by four triangles , the areas of which from the line zero pressure are as follows:

Suction stroke=0.45x 10^{-3} m^2;
Compression stroke=1.7x10^{-3} m^2;
Expansion stroke =6.8x $10^{-3}$$m^2$;
Exhaust stroke= 0.65x 10^{-3} m^2.
Each m^2 of areas represents 3x10^6N-m of energy.

Assuming the resisting torque to be uniform, find the mass of the rim of a fly wheel required to keep the speed between 202 rpm & 198 rpm. The radius of gyration may be taken equal to mean radius of rim=1.2m.

Ans: The turning moment-crank angle diagram as,



Given data,

a_1= 0.45x $10^{-3}m^2$

a_2= 1.7x $10^{-3}m^2$

a_3= 6.8x $10^{-3}m^2$

a_4= 0.65x $10^{-3}m^2$

N_1=202 rpm

N_2=198 rpm

R= 1.2m

∴ Net area=a3-(a1+a2+a4)=4x10^{-3} m^2

∵ the energy scale is

$1m^2$=3MN-m=3x10^6 N-m

∴ Net work done/cycle=4x10^{-3}x3x10^6=12x10^3 N-m-----------(i)

We also know that work done/cycle

= T_{mean}x4Π N-m---(ii)

From equations (i) & (ii)

T_{mean}=FG=12x10^3/4Π=955 N-m

Work done during expansion stroke

= $a_3$xenergy scale=6.8x 10^{-3}x3x10^6=20.4x10^3 N-m----------(iii)

Also work done during expansion stroke

=Area of ΔABC

=1/2 BC x AG=1/2xΠxAG---(iv)

From equation (iii) & (iv)

AG=20.4x10^3/1.571

AG=12985 N-m

∴ Excess torque,

T_{excess}=AF=AG-FG=12985-955=12030 N-m

Now from similar ΔADE & ΔABC

DE/BC=AF/AG or

DE=AF/AG x BC

= 12030/12985 x Π =2.9 rad

We know hat the maximum fluctuation of enery,

ΔE= Area of ΔADE

=1/2 x DE x AF=1/2 x 2.9 x12030=17444 N-m

Mass of the rim of a flywheel:-

Let, m=Mass of the rim of a flywheel in kg, &

N=Mean speed of flywheel

$=N_1+N_2/2=(202 + 198) / 2=200$

We know that the maximum fluctuation of energy (ΔE)

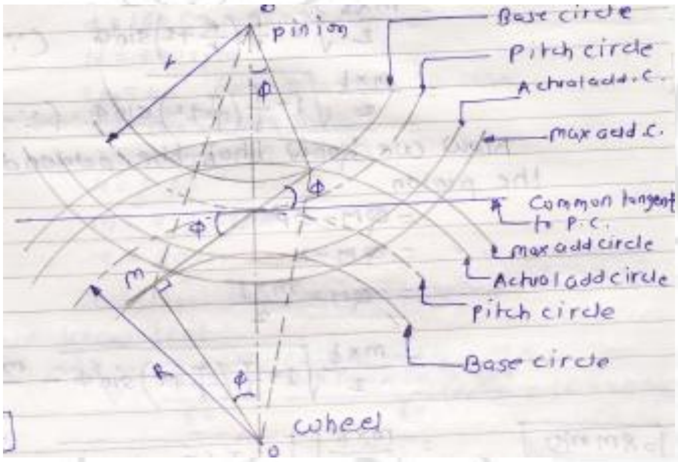
$(\Delta E) = \Pi^2/900 \times mR^2N(N_1\text{-}N_2)= \Pi^2/900 \times m(1.2)^2 \times 200\ (202\text{-}198)$

17444=12.63m

m= 1381 kg

Q.No. 5.a Derive an expression for the minimum number of teeth required on the pinion in order to avoid interference in involute gear teeth when it meshes with gear.

Ans:



Let, T=No. of teeth on the wheel.

t=No.of teeth on the pinion.

m=Module of teeth.

d=PCD of pinion=m xt.

r=PCR of pinion=d/2=m x t/2.

R=PCR of wheel=D/2=m x T/2.

G=Gear ratio=T/t=R/r.

Ø=Pressure angle.

The point Q is the center of pinion whereas point 'O' is the centre of wheel,

From ΔMPQ, which is towards pinion side,

We have,

$$QM^2 = QP^2 + PM^2 - 2QP\,xPM x\cos QPM$$

$$= r^2 + R^2\sin^2\emptyset - 2rR\sin\emptyset\cos(90+\emptyset)$$

$$= (r^2 + R^2\sin^2\emptyset + 2rR\,\sin^2\emptyset)$$

$$= r^2\left(1 + \frac{R^2\sin^2\emptyset + 2rR\,\sin^2\emptyset}{r^2}\right)$$

$$= r^2\left(1 + \frac{R}{r}\left(\frac{R}{r} + 2\right)\sin^2\emptyset\right)$$

$$\therefore QM = r\sqrt{\left(1 + \frac{R}{r}\left(\frac{R}{r} + 2\right)\sin^2\emptyset\right)}$$

$= \frac{mxt}{2}\sqrt{\left(1+\frac{R}{r}\left(\frac{R}{r}+2\right)\sin^2\emptyset\right)}$ ∴ ($r=\frac{mxt}{2}$)

$= \frac{mxt}{2}\sqrt{\left(1+\frac{T}{t}\left(\frac{T}{t}+2\right)\sin^2\emptyset\right)}$ ∵ $\left(\frac{R}{r}=\frac{T}{t}=G\right)$

Now we know that the addendum of the pinion

$= QM - QP$

$= QM - r$

$= QM - \frac{mt}{2}$

$= \frac{mxt}{2}\sqrt{\left(1+\frac{T}{t}\left(\frac{T}{t}+2\right)\sin^2\emptyset\right)} - \frac{mxt}{2}$

$= \frac{mxt}{2}\left(\sqrt{\left(1+\frac{T}{t}\left(\frac{T}{t}+2\right)\sin^2\emptyset\right)}-1\right)$ -------------(i)

Let Ap x m=Addendum of the pinion to avoid interference

Where, Ap=Fraction by which the standard addendum of one module for the pinion should be multiplied in order to avoid interference.

∴ Addendum of pinion=Ap x m-------------------------------------(ii)

Equating the two values of addendum of pinion given by equation (i) & (ii),we get

Ap x m $= \frac{mxt}{2}\left(\sqrt{\left(1+\frac{T}{t}\left(\frac{T}{t}+2\right)\sin^2\emptyset\right)}-1\right)$

Ap= $\frac{t}{2}\left(\sqrt{\left(1+\frac{T}{t}\left(\frac{T}{t}+2\right)\sin^2\emptyset\right)}-1\right)$

$t = \left[\frac{2Ap}{\left(\sqrt{\left(1+\frac{T}{t}\left(\frac{T}{t}+2\right)\sin^2\emptyset\right)}-1\right)}\right]$

$$t = \frac{2Ap}{\left(\sqrt{(1+G(G+2)\sin^2\emptyset)}-1\right)}$$

b) 100KW transmitted by a rope drive through a 160cm dia,45^0 grooved pulley running at 200rpm. & angle of overlap is 140^0. Coefficient of friction between the pulley and rope is μ=0.25. mass of rope is 0.7 Kg/m & it can withstand a tension of 800N. Considering the centrifugal tension induced determine:-

i) The number of ropes neeeded for transmitting the required power,

ii) The tension in rope before starting.

Ans: P=100 KW

d=160cm=160 x 10^{-2}m

N=200 rpm

2β=45^0

θ =140^0=140 x Π/180

μ=0.25

M=0.7 k/m

T=800N

Centrifugal tension considered,

We know that,

$$V = \frac{\pi dN}{60} = \frac{\pi\, x 160\, x 10^{-2} x 200}{60} = 16.755\ m/s$$

& Centrifugal tension,

$T_c = mv^2 = 0.7\ x\ (16.755)^2 = 196.5\ N$

& tension in tight side of rope

$T_1 = T - T_c = 800 - 196.5 = 603.5\ N$

Let, we know that,

$2.3 \log(\frac{T_1}{T_2}) = \mu\theta\ \text{cosec}\beta = 0.25\ x\ 140\ x\ \frac{\pi}{180}\ x\ \text{cosec}22.5$

$\therefore \frac{T_1}{T_2} = 4.9345$

$\therefore T_2 = \frac{603.5}{4.9345} = 122.302 N$

Power transmitted/rope= $\frac{(T_1 - T_2)v}{1000}\ KW = \frac{(603.5 - 122.3021)X16.755}{1000} = 8.062\ KW$

No. of ropes need= $\frac{Total\ power transmited}{Power\ ransmitted/rope} = \frac{100}{8.062} = 12.4 \approx 13$

i.e. 13 ropes n=13

Also, the initial tension in the rope before starting,

$T_0 = \frac{T_1 + T_2 + 2T_c}{2} = \frac{603.5 + 122.3021 + 2x196.5}{2}$

$T_0 = 559.4\ N$

Q.No. 6.a Derive the condition for transmitting the maximum power in a flat belt drive and find the velocity of belt for maximum power.

Ans: We know that power transmitted by a belt,

$P = (T_1 - T_2)\ V$-------------------------------------(i)

Where, T_1=Tension in the tight side of the belt in Newtons.

T_2=Tension in the slack side of the belt in Newtons.

V=Velocity of the belt in m/s

We know that,

Ratio of driving tension is

$\frac{T_1}{T_2} = e^{\mu\theta}$ or $T_2 = \frac{T_1}{e^{\mu\theta}}$-----------------------------(ii)

Substituting the value of T_2 in equation (i),We get

$P = \left(T_1 - \frac{T_1}{e^{\mu\theta}}\right) V$

$= T_1 \left(1 - \frac{1}{e^{\mu\theta}}\right) V = T_1 VC$----------------------(ii)

Where, C= $\left(1 - \frac{1}{e^{\mu\theta}}\right)$

We know that, $T_1 = T - T_c$

T = Max. Tension

T_c =Cetrifugal tension

Substituting the value of T_1 in eq^n(iii)

We get, $P = (T - T_c)VC$

$= (T - mV^2)VC$

$= (TV - mV^3)C$ (Sub $T_c = mV^2$)

For max. Power, differentiate the above expression with respect to V & equal to zero

$\frac{dp}{dv} = 0$ or $\frac{d}{dv}(TV - mV^3)C = 0$

$(T - mV^2) = 0$

$\therefore T - 3T_c = 0$ $\boxed{T = 3T_c}$

It shows that when the power transmitted is maximum, 1/3rd of maximum tension is absorbed as centrifugal tension

Also we know that,

$T_1 = T - T_c$ & for max. Power $T_c = T/3$

$T_1 = T - \frac{T}{3} = 2T/3$

Now from eq^n(iv), the velocity of the belt for the max.power:-

$$\boxed{V = \sqrt{\frac{T}{3m}}}$$

b)A pair of gears having 40 &20 teeth resp. are rotating in mesh, the speed of the smaller being 2000rpm. Determine the velocity of sliding between the gear faces at point of engagement, at the pitch point,& at the point of disengagement if the smaller gear is the driver. Assume that the gear teeth are 20^0 involute forms, addendum length is 5mm & the module is 5mm.

Also find the angle through which the pinion turns while any pairs of teeth are in contact.

Given data,

T=40

T=20

N_1=2000rpm

Ø=20^0

Add=5mm

m =5mm

We know that,

ω_1=2Π N_1/60=209.5 rad/s

ω_2= ω_1 xt/T=104.75rad/s

r=mt/2=50mm

R=mT/2=100mm

r_A=r+add=55mm

R_A=R+add=105mm

$$L_{PA} = \sqrt{R_A^2 - R^2\cos^2\emptyset} - R\sin\emptyset = 12.65mm$$

$$L_{PR} = \sqrt{r_A^2 - r^2\cos^2\emptyset} - r\sin\emptyset = 11.5mm$$

Velocity of sliding a the point of engagement, V_{s1}=(ω_1 + ω_2) x L_{PA}=3975mm/s

Velocity of sliding a the pitch point, V_s=0mm/s

Velocity of sliding a the point of disengagement, V_{s2}=(ω_1 + ω_2) x L_{PR}=3614mm/s

Angle through which the pinion turns,

We know that,

$L_{PC} = L_{PA} + L_{PR} = 12.65 + 11.5 = 24.15mm$

$$L_{AC} = \frac{L_{PC}}{\cos\emptyset} = 25.7mm$$

Circumference of the smaller gear or pinion=2Πr=2Πx50=314.2mm

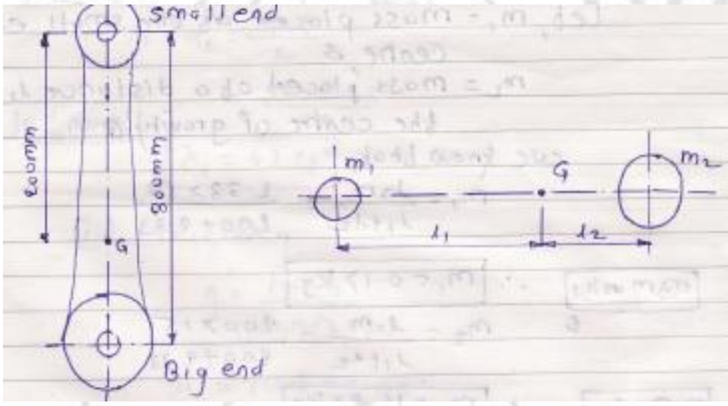
∴ Angle through which he pinion turns

$$= \frac{L_{AC} X\ 360}{Circumference\ of\ pinion} = 25.7x\frac{360}{314.2} = 29.45^0$$

$\boxed{\theta = 29.45^0}$

Q.No. 7.a connecting rod of a engine is 300mm long between its centers. It has a mass of 15kg and mass moment of inertia 7000kg-mm^2.Its center of gravity is 200mm from its small end center. Determine the dynamically equivalent two-mass system of the connecting rod if one of mass is located at the small end centre.

Ans:



Given data,

l=300 mm

m=15kg

I=7000 kg-mm^2

l_1=200mm

Let, K_G=Radius of gyration

We know that,

$I=mK^2_G$

∴ K^2_G=466.7 mm^2

K_G=21.6mm

We know that for a dynamical equivalent system,

$l_1 l_2=K^2_G$

l_2=466.7/200=2.33mm

Let, m_1=Mass placed at the small end center ,&

m_2=Mass placed at the distance l_2 from the center of gravity G

We know that,

$m_1= l_2 m/(l_1+l_2)$

m_1=0.17 kg.

m_2= $l_1 m/(l_1+l_2)$

m_2=14.83 kg.

b)A two-start worm rotating at 800rpm drives a 26 tooth worm gear. The worm has a pitch dia.of 54mm & a pitch of 18mm.If coeff.of friction μ=0.06 then find,

i) Helix angle of worm

ii) Lead angle for max. efficiency

iii) Efficiency

iv) Max efficiency

Ans:

N_1=800 rpm

P_1=18 mm

d_1=54mm

μ=0.06

i) Helix angle of worm(α_1)=78.02^0

ii) Lead angle for max. efficiency (λ_1)=43.29^0

iii) Efficiency (η)=0.77 or 77%

iv) Max efficiency(η_{max})=0.887 or 88.7%