NOTRE DAME UNIVERSITY (NDU)
FACULTY OF ENGINEERING
MECHANICAL DEPARTMENT

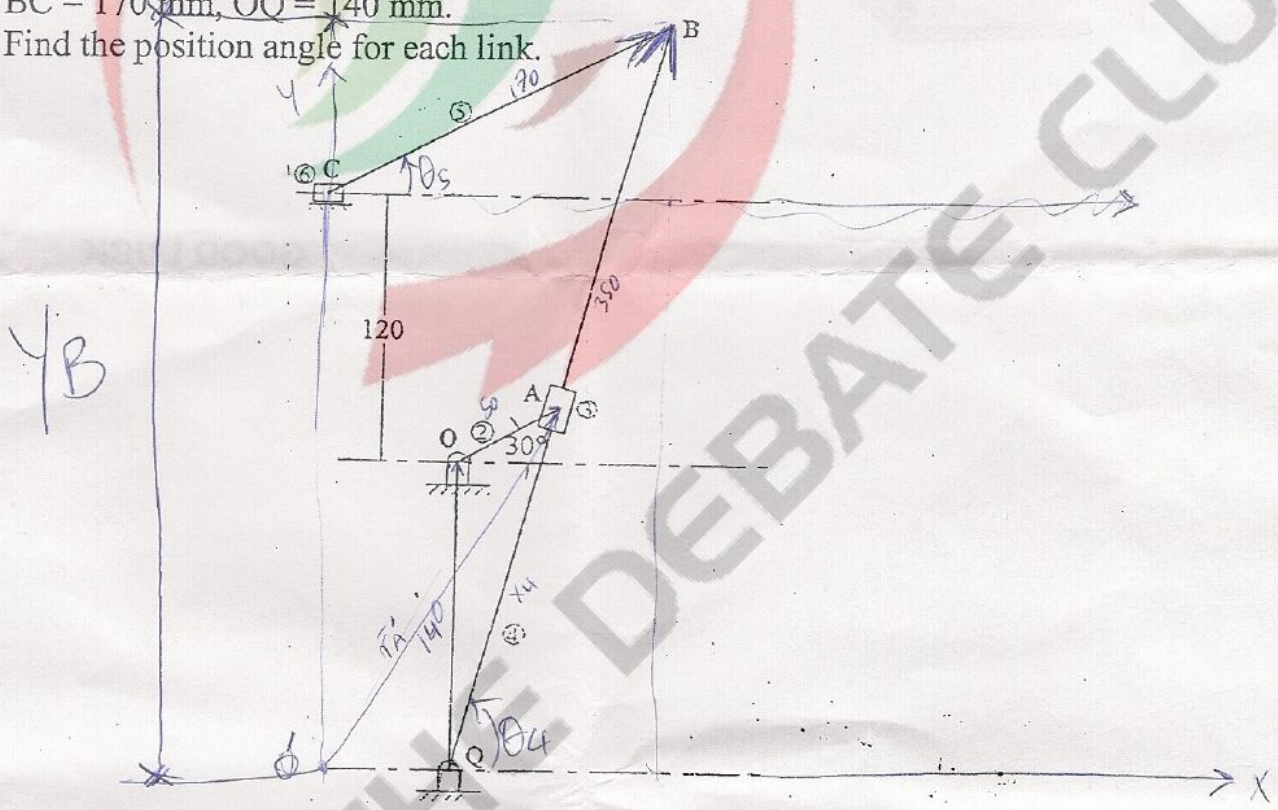
MIDTERM-1- **DATE 19/03/2010**

MECHANISMS AND DYNAMICS OF MACHINERY
COURSE CODE : MEN 430 **TIME ALLOWED: 1Hr.**
INSTRUCTOR : **CLOSED BOOK**

ANSWER THESE QUESTIONS

QUESTION – 1- (12 points)

For the plane mechanism shown in figure, OA = 50 mm, QB = 350 mm, BC = 170 mm, OQ = 140 mm.
Find the position angle for each link.

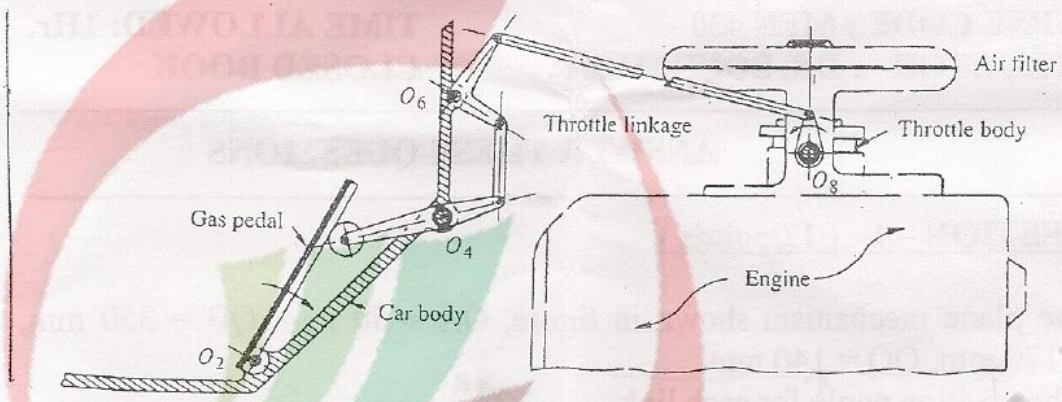


QUESTION – 2- (8 points)

Use number synthesis to find all the possible link combinations for 2-DOF, up to 9 links, to hexagonal order, using only revolute joints.

QUESTION – 3- (5 points)

Find the mobility of the automotive throttle mechanism shown in figure.



GOOD LUCK

Question I

$OA = r_2 = 50$

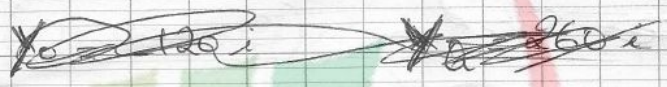
$AB = r_4 = 350$

$BC = r_5 = 170$

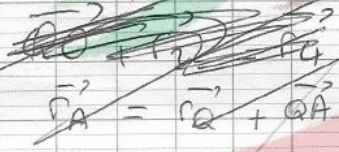
$OQ = 140$

$\theta_2 = 30$

* lets start first with setting the x-y axis at O'



Loop O'AQ: Shape: h=0



$\vec{r_A} = \vec{r_Q} + \vec{QA}$

$C(\ ; 260)$ $\quad O(X_0 ; 140)$

$A(X_A ; 140 + 50\sin 30)$ $\quad Q(X_Q ; 0)$

$B(170\cos\theta_5 ; 260 + 170\sin\theta_5)$

Loop OAQ: $h = 0$

$\vec{QO} + \vec{r_2} = \vec{r_4}$

~~multiplying by conjugate~~

$(X_4)e^{i\theta_4} = (X_0 + Y_0 i) + (X_2 + i Y_2)$

$X_4 e^{i\theta_4} = (0 + 140i) + (50\cos 30 + i\, 50\sin 30)$

Multiply by conjugate $\left(X_4 e^{i\theta_4}\right)\left(X_4 e^{-i\theta_4}\right) = \left[50\cos 30 + i(50\sin 30 + 140)\right]$

$\times \left[50\cos 30 - i(50\sin 30 + 140)\right]$

$X_4 = \sqrt{(50\cos 30)^2 + (50\sin 30 + 140)^2}$

$X_4 = \sqrt{43.3^2 + 165^2} \Rightarrow \boxed{X_4 = 170.58}$

$e^{i\theta_4} = \dfrac{50\cos 30 + i(50\sin 30 + 140)}{X_4}$

$\cos\theta_4 = \dfrac{50\cos 30}{X_4} = 0.2547$ $\left.\begin{matrix}\cos>0\\ \sin>0\end{matrix}\right\} \Rightarrow$ 1st quadrant

$\sin\theta_4 = 0.967 \Rightarrow \theta_4 = 75.3°$

$\theta_4 = 75.3$

Loop CBQ : 4-bar:

$\vec{QC} + \vec{r_5} = \vec{r_4}$ $\left.\begin{matrix}\\ \\ \end{matrix}\right\}$ let $d = QC$

$\vec{QC} = \vec{r_4} - \vec{r_5}$

$de^{i\theta_d} = (r_4\cos\theta_4 + i\, r_4\sin\theta_4) - (r_5\cos\theta_5 + i\, r_5\sin\theta_5)$

Multiplying by conjugate :

$de^{i\theta_d} \cdot de^{-i\theta_d} = \left[(r_4\cos\theta_4 - r_5\cos\theta_5) + i(r_4\sin\theta_4 - r_5\sin\theta_5\right.$

$* \left[(r_4\cos\theta_4 - r_5\cos\theta_5) - i(r_4\sin\theta_4 - r_5\sin\theta_5\right.$

Due to Graph we can see $\Rightarrow$

~~We can see here that:~~

From 4B

We can see that:

$$\Rightarrow QB \sin\theta_4 = (120 + 140 + CB \sin\theta_5)$$

$$350 \sin 75.3 = 260 + 170 \sin\theta_5$$

$$\sin\theta_5 = \frac{350 \sin 75.3 - 260}{170} = 0.462$$

θ_5 is in 1st quadrant: $\boxed{\theta_5 = 27.5°}$

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Course N°: Theory of Machines Section: [redacted]

Grade:

Date: 19/03/2010

Question 2

Consider all joints are full joints, An even number of DOF Requires an odd number of Links:

Consider * $\boxed{L = B + T + Q + P + H}$ Combination of Links

* And $\boxed{L - 3 - M = T + 2Q + 3P + 4H}$ mobility eq.

derived from $J = \frac{nodes}{2}$

Consider: * $L = 1$

$L - 5 = T + 2Q + 3P + 4H = -4 \Rightarrow$ 2 possible Link Combination.

* $L = 3$: $L - 5 = T + 2Q + 3P + 4H = -2$
$\Rightarrow$ 2 possible Link Combination

* $L = 5$:
$L - 5 = T + 2Q + 3P + 4H = 0$
This leads To $T = Q = P = H = 0$
this leaves us with: $\boxed{L - B = 5} \Rightarrow 1^{st}$ solution.

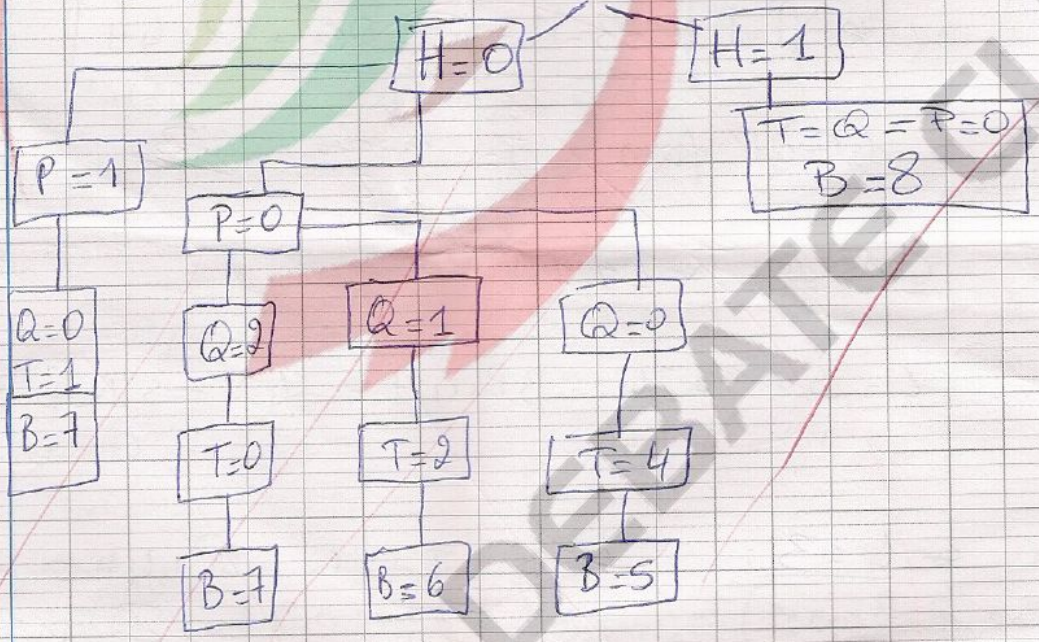
* $L = 7$:
$L - 5 = T + 2Q + 3P + 4H = 2$
Obviously $\Rightarrow$ $P \neq H = 0$

This leaves us with 2 solutions:

with $\begin{cases} Q=0 \Rightarrow T=2 \Rightarrow L=B+T=7 \\ \quad B=7-2 \Rightarrow B=5 \\ Q=1 \Rightarrow T=0 \Rightarrow L=B+1=7 \\ \quad \Rightarrow B=6 \end{cases}$

$L=9$

$L-S=T+2Q+3P+4H=4$



We end up with:

$L=5 \Rightarrow$ 1 solution

$L=7 \Rightarrow$ 2 solutions

$L=9 \Rightarrow$ 5 solutions.

Question 3:

$M = 3(L-1) - 2J$

$L = 8$

$J = 10$

$M = 3(8-1) - 2(10)$

$\boxed{M = 1}$