TE (Mechanical) - First half 2018 Examination

Subject - Kinematics of machinery

3 hrs. Solution key Marks : 80

Q.P. Code - 21791

Q 1. Attempt any four.

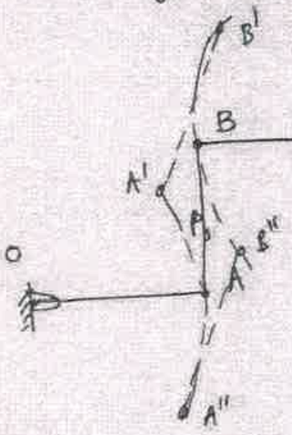
A) DOF :- Minimum number of coordinates required to define motion of system or No of input required for constrained motion. (1)

Kutzbach criteria DOF; $F = 3(N-1) - 2P_1$ (2)

for single slider, $N = 4$, $P_1 = 4$

$\therefore F = 1$

B)



$$\frac{PA}{PB} = \frac{QB}{OA}$$ (2)

C) It is a centre of rotation of body at a instant.

No of instataneous centre $N = \frac{n(n-1)}{2}$, where n = no of links. (2)

D) Law of Gearing

Component of velocity & relative velocity along common normal

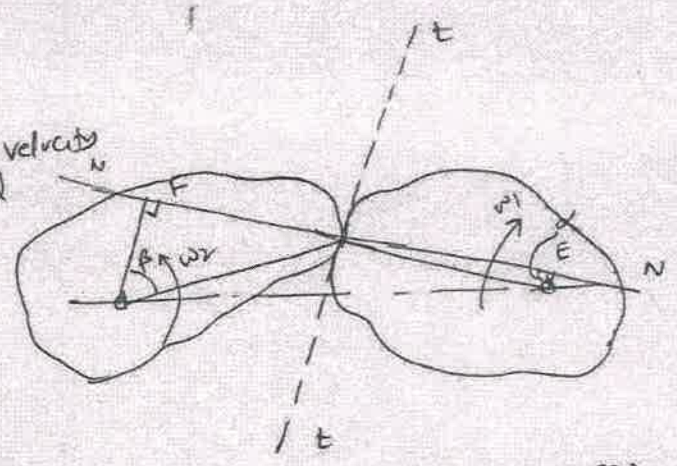
$V_c \cos\alpha - V_d \cos\beta = 0$

$\omega_1 AC \cos\alpha - \omega_2 BD \cos\beta = 0$

$\omega_1 AC \cdot \frac{AE}{AC} = \omega_2 BD \frac{BF}{BD} = 0$

$\therefore \omega_1 AE = \omega_2 BF$

$\therefore \frac{\omega_1}{\omega_2} = \frac{BF}{AE} = \frac{BP}{AP}$



(2)

Q 1. E) when centrifugal tension considered

$$T - T_c = T_1 \quad \& \quad \frac{T_1}{T_2} = e^{\mu\theta} = K \quad \text{or} \quad T_2 = \frac{T_1}{K}$$

$$\therefore \quad P = (T_1 - T_2)v = \left(T_1 - \frac{T_1}{K}\right)v = T_1\left(1 - \frac{1}{K}\right)v$$

when T_C neglected

Friction Tension on tight side = T (2)

$$P = (T_1 - T_2')v = \left(T - \frac{T}{K}\right)v = T\left(1 - \frac{1}{K}\right)v$$

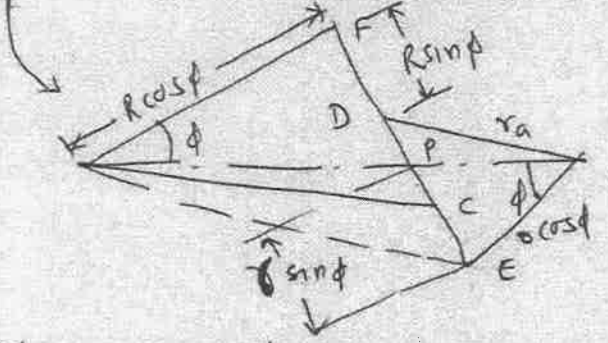
As $T_1 < T$, power transmitted is less when centrifugal tension considered

Q 2(A)

$$R = \frac{mT}{2} = 250\text{ mm} \quad ; \quad R_a = 250 + 10 = 260\text{ mm}$$

$$r = \frac{mt}{2} = 65\text{ mm}$$

i) $R_{a\,max} = \sqrt{(R\cos\phi)^2 + (R\sin\phi + r\sin\phi)^2} = 258.45$ mm. (2)



(3)

The actual addendum R_a is more than max $R_{a(max)}$ & therefore interference occure.

ii) Max R_a can be found using

$$R_{a\,max} = R\sqrt{1 + \frac{t}{T}\left(\frac{t}{T} + 2\right)\sin^2\phi} = 258.45\text{ mm}$$

The new value of ϕ can be found by taking $R_{a\,max}$ equal to R_a

$$\therefore \quad 260 = \sqrt{(250\cos\phi)^2 + (315\sin\phi)^2}$$

(5)

$$\therefore \quad \cos\phi = 0.928 \quad \& \quad \phi = 21.88^\circ.$$

Thus if ϕ increases to 21.88°, the interference can be avoided.

Q 2(B) Law of Belting :- The Centre line of belt when it approaches a pulley must lie in the mid plane of that pulley. However the belt leaving the pulley may be drawn out of plane of pulley.

(5)

Q 2 (c) + A brake where no force is required to apply brake or just contact is enough to apply brake is a self locking brake.

(05)

\+ The moment of applied force and in moment of frictional force, is self energizing brake.

c5)

Q 3 (A)

Using $\frac{T_1}{T_2} = e^{\mu\theta}$ & $T_1 - T_2 = 1215$ — using Power. — (3)

& contact angle $\theta = \pi - 2\beta = \pi - 2\sin^{-1}\left(\frac{R_2 - R_1}{c}\right)$ — (2)

$\theta = 2.79$

Using $\frac{T_1}{T_2} = e^{0.25 \times 2.79}$

$T_1 = 2418\ N$ & $T_2 = 1203\ N.$ — (2)

$T_c = mv^2$ = mass/unit length $\times v^2$ = volume/unit length × density × v^2

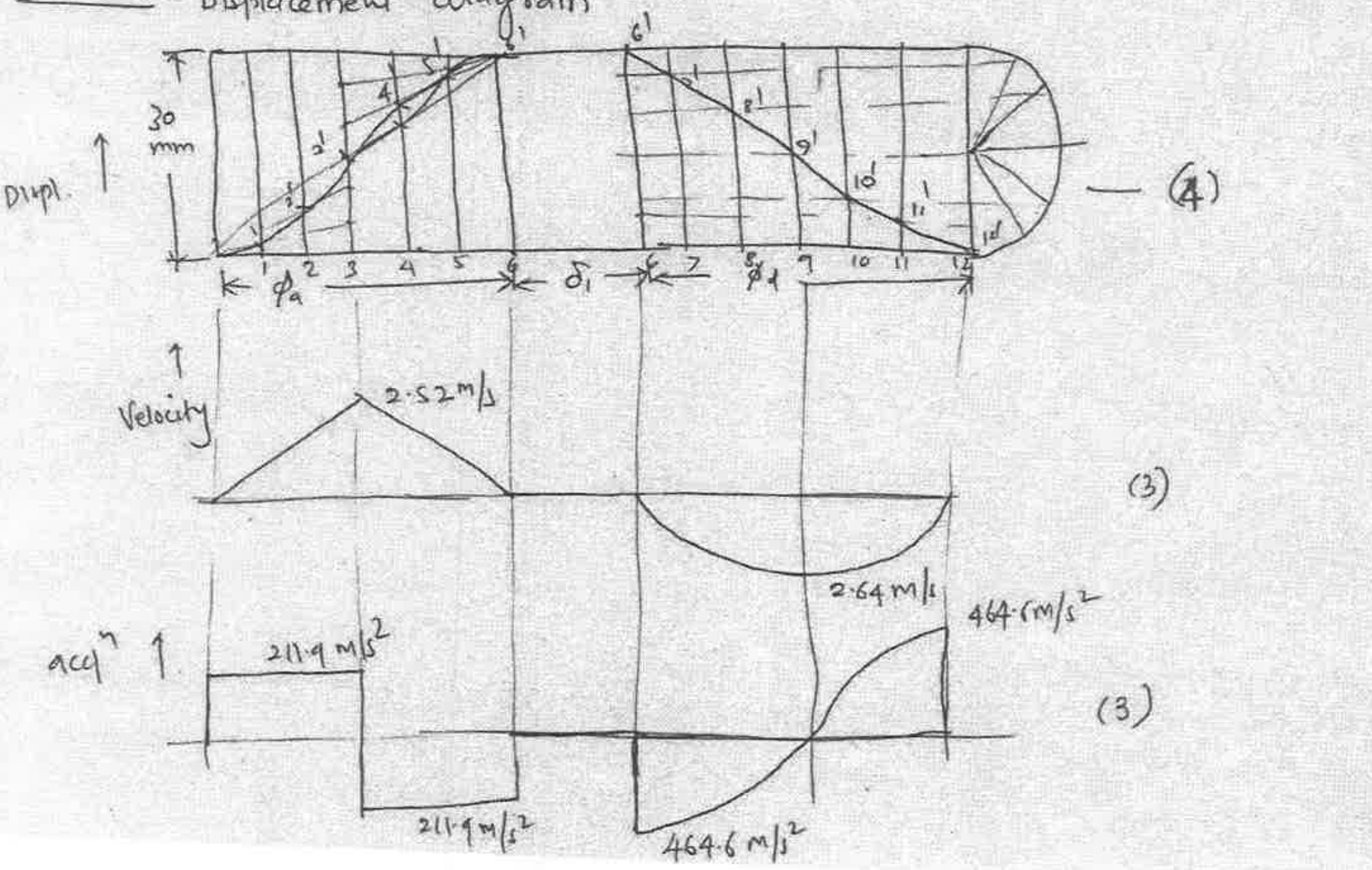
$= 6 \times 0.012 \times 1 \times 1000 \times (8.23)^2 = 812.86\ N$

$T = T_1 + T_c = \sigma_t \times (b \times t)$

$29187\ b = 2418$ — (3)

$\therefore b = 82.8\ mm$

Q 3 (B) Displacement diagram



— (4)

(3)

(3)

(06)

Q4(A) Any method — i) Tabular or ii) Relative velocity method.

i) Tabular method :

Action	a	s	p	A
a fixed, S+1 rev	0	1	$-\frac{80}{T_p}$	$-\frac{80}{T_p}\times\frac{T_p}{T_A} = -\frac{80}{T_A}$
a fixed s +x rev	0	x	$-\frac{80x}{T_p}$	$-\frac{80x}{T_p}$
All given y rev	y	$x+y$	$y-\frac{80x}{T_p}$	$y-\frac{80x}{T_p}$

← (4)

Given: $N_a = y = 180$ rpm — speed of arm

$N_s = y + x = 0$ & $N_A = y - \frac{80x}{T_A} = 300$ (3)

↓ $x = -y = -180$

solving for N_A ; $T_A = 120$

The pitch diameters of wheel are proportional to number of teeth on them

$T_s + 2T_p = T_A$; $80 + 2T_p = 120$ ∴ $T_p = 20$ (3)

ii) Relative velocity method:

The ratio of relative speed is related as

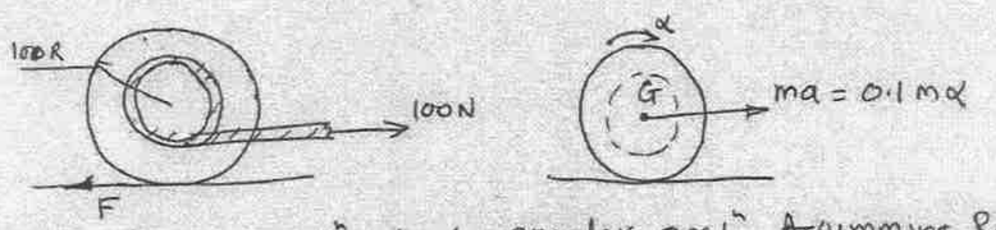
$$\frac{N_A - N_a}{N_s - N_a} = -\frac{T_s}{T_p}\times\frac{T_p}{T_A} = -\frac{80}{T_A} \;;\; \frac{300-180}{0-180} = -\frac{80}{T_A}$$ (07)

∴ $T_A = 120$

The pitch dia are related to number of teeth as

$T_s + 2T_p = T_A$; $T_p = 120$ —— (3)

Q4(B)



(2)

Let a = linear accl^n & α = angular accl^n, Assumming Rolling without slipping ; $a = r\alpha = 0.1\alpha$, $I = mk^2 = 30\times0.075^2 = 0.16875$ kg·m².

Applying Newton's Second Law / D'Alembert's principle

$100 - F = 0.1\,m\alpha = 0.1\times30\times\alpha = 3\alpha$

∴ $F = 100 - 3\alpha$ —— (I) —— (3)

(07)

Q 4(B) Continued

$\Sigma M_G = 0$

$F \times 0.1 - 100 \times 0.07 = \bar{I} \cdot \alpha = 0.16875\alpha$

$\therefore F = 70 + 1.6875\alpha$ —— (II) — (3)

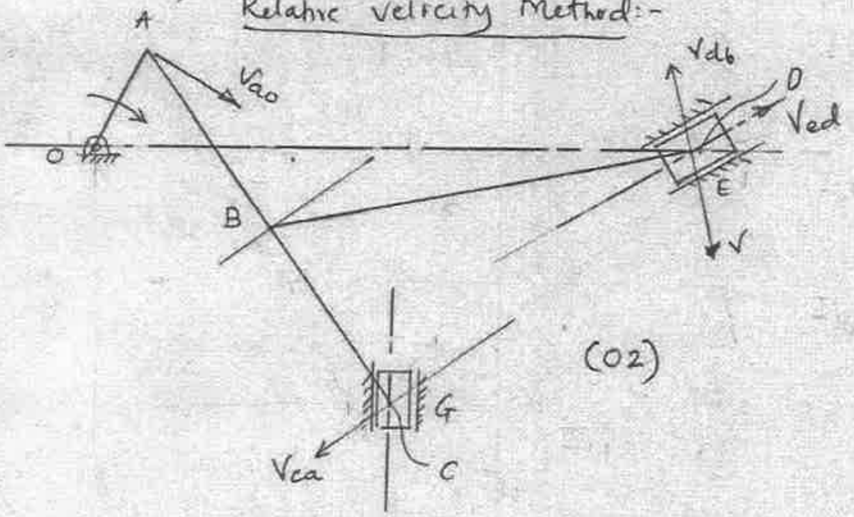
Solving I & II

$\alpha = 6.4\ rad/s^2$ (↺) — (2)

$F = 80.8\ N$ (⟵)

Q 5(A) i) For configuration scale 1:200

Relative velocity method:-

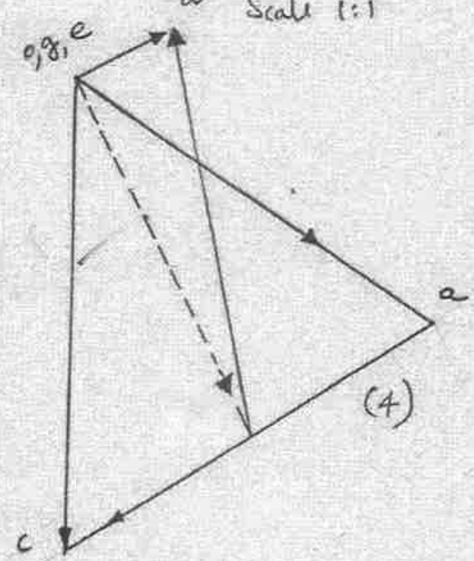


(02)

$\omega_{oa} = 20.94$ rad/sec

$V_a = \omega_a OA = 6.28$ m/s

Scale 1:1



(4)

$\overline{ed} = 1.5$, V_{ed} = Velocity of slider $= 1.5$ m/s ∠30° (01)

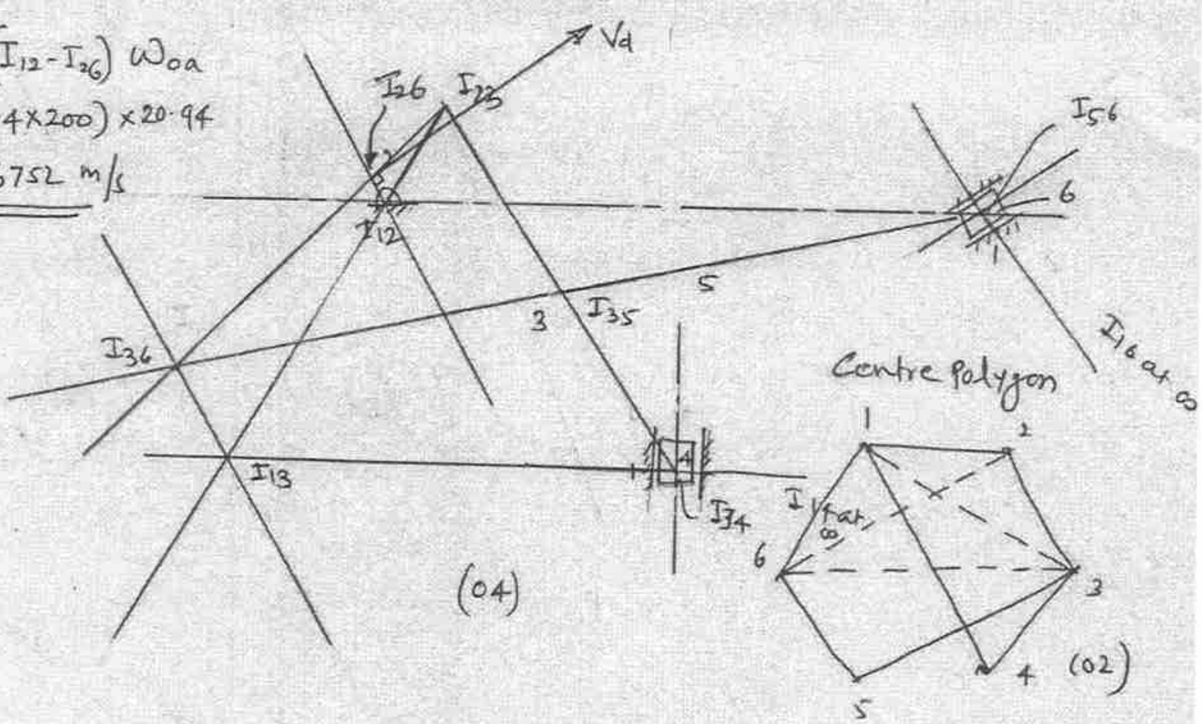
ii) Instataneous Centre method

$V_{slider(d)} = (I_{12} - I_{26})\,\omega_{oa}$

$= (0.4 \times 200) \times 20.94$

$= 1.6752$ m/s

(01)



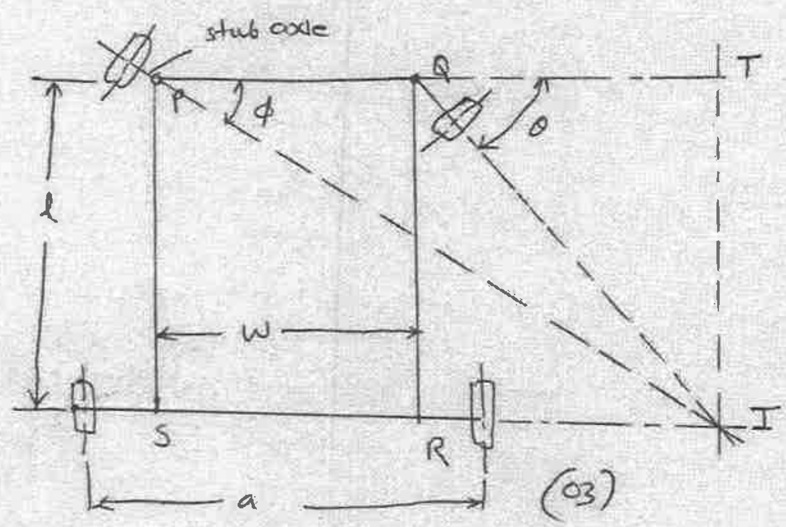
(04)

Centre Polygon

(02)

Q 5 (B)

(08) ⑥



(03)

θ & ϕ angle turned by stub axle

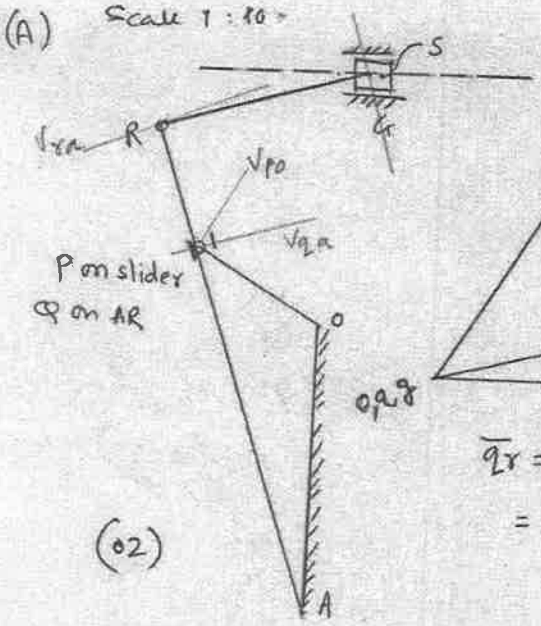
$\cot\phi = \frac{PT}{TI}$ & $\cot\theta = \frac{QT}{TI}$

$\cot\phi - \cot\theta = \frac{PT - QT}{TI} = \frac{PQ}{TI} = \frac{W}{l}$

↑ Condition for correct gearing.

(03)

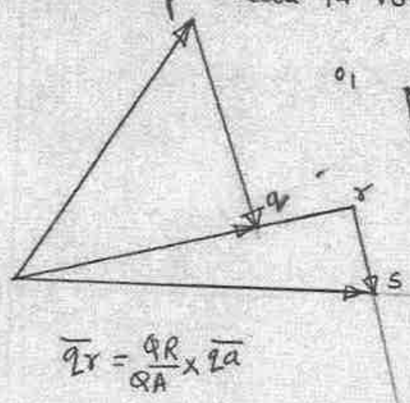
Q 6 (A) Scale 1 : 10



(02)

$V_{PO} = \omega \cdot OP = 4.4\ m/s$

Scale for velocity - 1:1

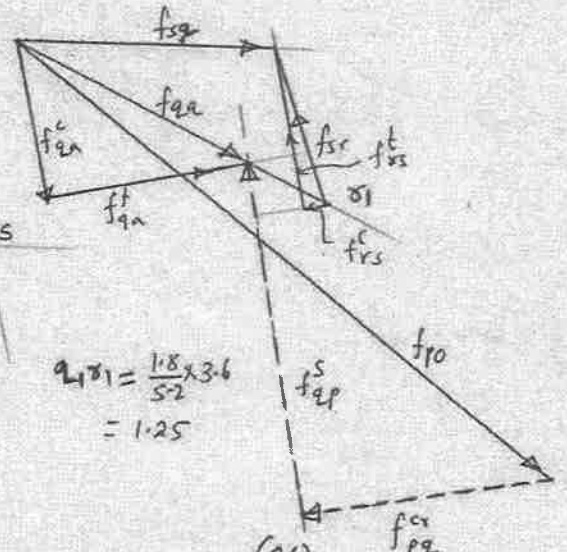


$\overline{qr} = \frac{QR}{QA} \times \overline{qa}$

$= 1.35$

(04)

for Accl^n diagram scale 1:10



$q_1 r_1 = \frac{1.8}{5.2} \times 3.6$

$= 1.25$

(04)

For Accl^n, the vector table as below.

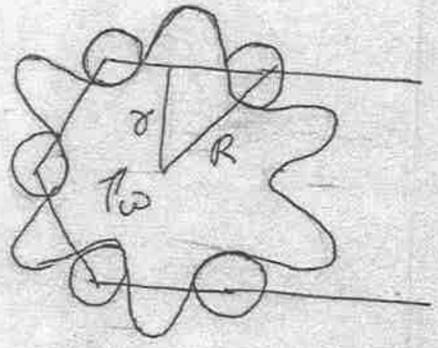
Sr No.	Vector	Magnitude	Direction	Sense
1	f^c_{po} or $o_1 p_1$	$\frac{(op)^2}{OP} = \frac{(4.4)^2}{0.2} = 96.8$	∥ OP	→ O
2	f^{cr}_{qp} or $p_1 q_p$	$2\omega \cdot V_{qp} = 35.5$	⊥ AQ	f^{cr}_{qp}, 90°, V_{qp}
3	f^s_{qp} or $q_p q_1$	–	∥ AQ	–
4	f^c_{qa} or $a_1 q_a$	$\frac{(aq)^2}{AQ} = \frac{(3.45)^2}{0.52} = 22.88$	∥ AQ	→ A
5	f^t_{qa} or $q_a q_1$	–	⊥ AQ	–
6	f^c_{rs} or $r_1 s_r$	$\frac{(rs)^2}{RS} = \frac{(1.2)^2}{0.7} = 2.05$	∥ to RS	→ R

(02)

The accl^n of slider $= 3.6 \times 10 = \underline{36\ m/s^2}$

Angular accl^n of link Rs $= \frac{2.3 \times 10}{0.3} = \underline{76.6\ rad/sec}$ ——— (02)

Q 6 B Chordal Action in chain drive   ⑦



The radius from Centre of sprocket differs when chain engage in tangent position and when engages in chord. This will lead to fluctuation in speed, which lead to vibration in the chain.

(2) The chordal action is based on number of teeth in sprockets:

$$\text{Ratio of speed change} = \frac{V_{max} - V_{min}}{V_{max}} = 1 - \cos\left(\frac{180^\circ}{N}\right) \quad \text{—④}$$

——— x x ———

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