MCG 3130
DGD 6 (KINOSTATIC)

Nov 7th 2014.

Pls Note:

First Question is the **BOARD PROBLEM QUESTION**

Second question, will be the **ASSIGNED QUESTIONS** To **Students**

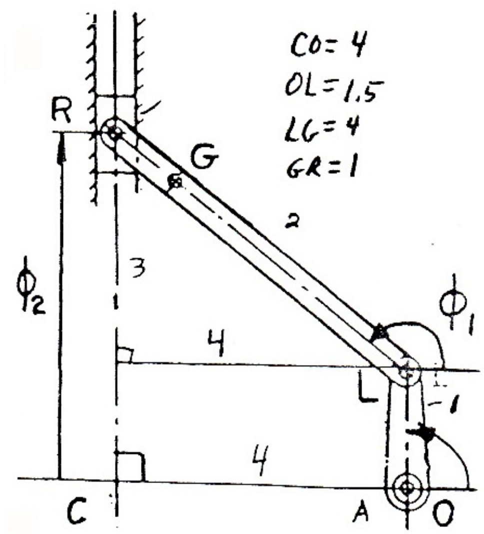
BOARD QUESTION 1:

´. For the mechanism of Fig. 3 OL is a crank with fixed axis at O, and LR is a connecting rod pinned to a slider at R which slides in fixed vertical guides. CO=4 cm, OL=1.5 cm, LG=4 cm, and GR=1 cm. At the instant of consideration OL is vertical and CR=4.5 cm. Crank OL is balanced. Link LR, with center of mass at G, has a mass of $m_2 = 0.2kg$, and a mass moment of inertia about G of $I_{2z} = 0.1kg.cm^2$. The slider R has a mass of $m_3 = 0.1kg$. A kinematic analysis has provided the following information at this instant: $\dot{q} = 2rad/s$ counterclockwise (cnst.), $\dot{\phi}_1 = -1$ rad/s, $\ddot{\phi}_1 = 1.33\ rad/s^2$, $\dot{\phi}_2 = 4$ cm/s, $\ddot{\phi}_2 = -14.3\ cm/s^2$. Ignoring effects of friction and gravity determine for this instant

(a) the D'Alembert force sets for the connnecting rod LR and the slider R,

(b) the necessary driving torque T on link OL,

(c) the forces at the pins O, L, and R.

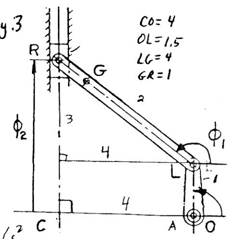


Solution:

SOLN:

(a) D'Alembert force sets links 2 & 3

Fig.3



CO = 4
OL = 1.5
LG = 4
GR = 1

$x_{G2} = 1.5\cos q + 4\cos\phi_1$

$y_{G2} = 1.5\sin q + 4\sin\phi_1$

$\dot{x}_{G2} = -1.5\sin q\,\dot{q} - 4\sin\phi_1\,\dot{\phi}_1 = -1.5(1)(2) - 4(.6004)(-1) = -.598$

$\dot{y}_{G2} = 1.5\cos q\,\dot{q} + 4\cos\phi_1\,\dot{\phi}_1 = 1.5(0) + 4(-.8)(-1) = 3.2$

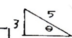
$\ddot{x}_{G2} = -1.5\sin q\,\ddot{q} - 1.5\cos q\,\dot{q}^2 - 4\sin\phi_1\,\ddot{\phi}_1 - 4\cos\phi_1\,\dot{\phi}_1^2$

$= -1.5(1)0 - 1.5(0) - 4(.6004)1.33 - 4(-.8)(1) = .008\ cm/s^2$

$\ddot{y}_{G2} = 1.5\cos q\,\ddot{q} - 1.5\sin q\,\dot{q}^2 + 4\cos\phi_1\,\ddot{\phi}_1 - 4\sin\phi_1\,\dot{\phi}_1^2$

$= 1.5(0) - 1.5(1)4 + 4(-.8)1.33 - 4(.6004)(1) = -12.7\ cm/s^2$

$\}\ \phi_1 = 143.1°$ $\quad q = 90°$



$\cos\theta = 0$
$\theta = 36.8$

$F_{D2} = -m_2 a_{G2} = -0.2(\ddot{x}_{G2}\,i + \ddot{y}_{G2}\,j) = \boxed{(-0.0016\,i + 2.54\,j)\times10^{-2}N}$ (F_{2x}, F_{2y})

$C_{D2} = -I_{23}\,\alpha_2\,k = -0.1\times10^{-4}(1.33)\,k = \boxed{-0.133\times10^{-4}\,k\ Nm}$

$F_{D3} = -m_3\,a_{G3} = -0.1(-14.3\,j)\times10^{-2} = \boxed{1.43\times10^{-2}\,j\ N}$

$C_{D3} = 0 \qquad \boxed{0\,k}$

$\dot{q} = 2 \qquad \ddot{q} = 0$

$\dot{\phi}_1 = -1 \qquad \ddot{\phi}_1 = 1.$

$\dot{\phi}_2 = 4 \qquad \ddot{\phi}_2 = -1$

(b) PVW $\quad \Sigma\,T\cdot\omega + \Sigma\,F\cdot V = 0$

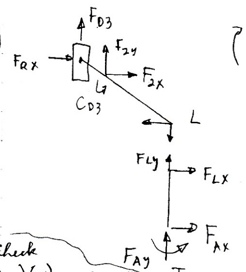
$T_1 k\cdot\dot{q}\,k + C_{D2}\cdot\dot{\phi}_1 k + F_{D2}\cdot(\dot{x}_{G2}\,i + \dot{y}_{G2}\,j) + F_{D3}\cdot\dot{\phi}_2\,j = 0$

ie $\quad T_1(2) + (-.133\times10^{-4})(-1) + (0\,i + 2.54\,j)\cdot(-.6\,i + 3.2\,j)\times10^{-4} + (1.43)(4)\times10^{-4} = 0$

$T_1 = -\frac{1}{2}[.133 + 8.13 + 5.72]\times10^{-4}$ $\quad \boxed{T_1 = -7\times10^{-4}\ Nm}$

Forces in Coupler

(c)



$\curvearrowleft \Sigma M_L = 0 \qquad 3F_{Rx} + 4F_{D3} + 2.4F_{2x} + 3.2F_{2y} = 0$

$F_{Rx} = -\frac{10^{-2}}{3}[4(1.43) + 2.4(0) + 3.2(2.54)] = -4.62\times10^{-2}$

$\rightarrow \Sigma F_x = 0 \qquad -F_{Lx} + F_{2x} + F_{Rx} = 0$

$F_{Lx} = -4.62$

$\uparrow \Sigma F_y = 0 \qquad -F_{Ly} + F_{2y} + F_{D3} = 0$

$F_{Ly} = 2.54 + 1.43$

$F_{D3} = 1.4 \times10^{-2}$

$F_{Lx} = -4.62\times10^{-2}$

$F_{Ly} = 3.97\times10^{-2}$

$\Sigma F_x = 0 \qquad F_{Lx} + F_{Ax} = 0$

$\Sigma F_y = 0 \qquad F_{Ly} + F_{Ay} = 0$

$F_{Ax} = 4.62\times10^{-2}$

$F_{Ay} = -3.97\times10^{-2}$

Check
$(F_{Ax})(OL) = 6.93\times10^{-4}$
$\simeq 7\times10^{-4}$

ASSIGNED QUESTION 2:

The link lengths and constant distances for the mechanism of Fig. 2 are given by $r_1 = 3.4cm$, $r_2 = 6.0cm$, $\ell_1 = 3.25cm$, $\ell_2 = 3.72cm$, and $c_1 = 4.2cm$. Link BCD has angle CBD= 34^o, and the side DC vertical at the instant shown. At this instant the mechanism position is given by $q = 15^o$, $\phi_1 = 299^o$, $\phi_2 = 6.2cm$. Link 1 is a uniform member of mass $m_1 = 0.1kg$. Link 2, with center of mass at D, has a mass of $m_2 = 0.2kg$, and a mass moment of inertia about D of $I_{2z} = 0.1kg.cm^2$. The slider (link 3) has a mass of $m_3 = 0.2kg$. A kinematic analysis has provided the following information for the motion of the linkage: $\dot{q} = 10rad/s$ CCW (cnst.), $\dot{\phi}_1 = -11.3$ rad/s, $\ddot{\phi}_1 = -200\ rad/s^2$, $\dot{\phi}_2 = 68.1$ cm/s (to left), $\ddot{\phi}_2 = 1750\ cm/s^2$ (to left). Ignoring effects of friction and gravity determine for this instant

(a) the D'Alembert force set corresponding to each of the three links,

(b) the necessary driving torque T_1 on link 1.

(c) the forces at the pins A, B, and C.

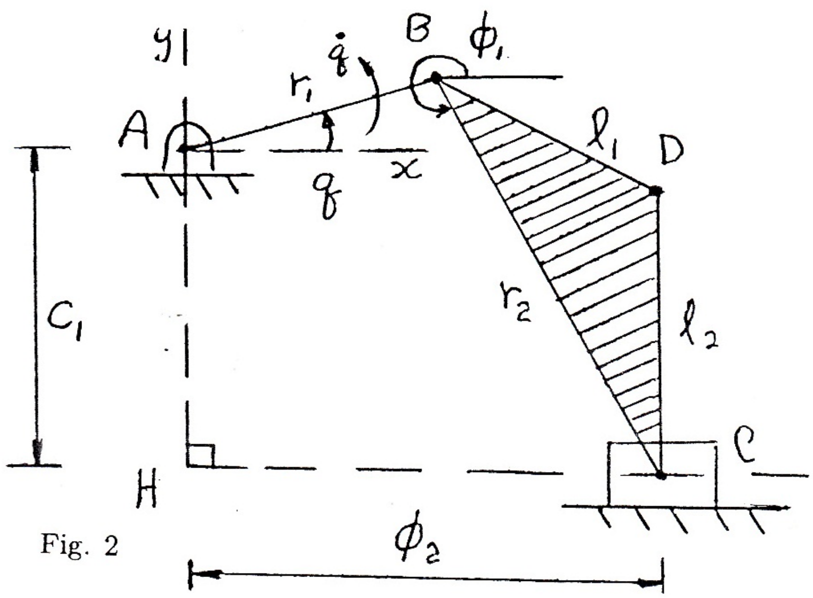


Fig. 2

Solution:

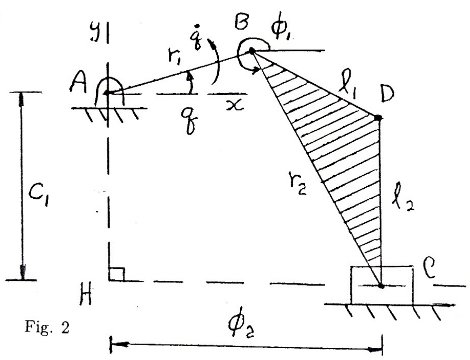


Fig. 2

(a) D'Alembert force sets

$a_{G1} = -\dot{q}^2 \frac{AB}{2} e_{AB}$
$= -172\cos 15^\circ i - 172 \sin 15^\circ j$
$= -166 i - 44.5 j$ cm/s

$a_{G2} = a_D = a_C + a_{D/C}$
$= -1750 i + \ddot{\phi}_1 l_2(+i) + \dot{\phi}_1^2 l_2(-j)$
$= -1006 i - 475 j$

Link 1 $F_{01} = (.166 i + .045 j)N$
$C_{01} = 0$

Link 2 $F_{02} = (2.01 i + 0.95 j)N$
$C_{02} = +200 \times 10^{-5} k$ Nm $= 0.002$ Nm

Link 3 $F_{03} = +3.5 i$ N
$C_{03} = 0$

(k, i, j)

$r_1 = 3.4$ $\angle CBD = 34^\circ$
$r_2 = 6.0$ $\angle HCD = 90^\circ$
$l_1 = 3.25$ $q = 15^\circ$
$l_2 = 3.72$ $\phi_1 = 249^\circ$
$c_1 = 4.2$ $\phi_2 = 6.2$
$m_1 = 0.1$ I
$m_2 = 0.2$ $I_{32} = 0.1$
$m_3 = 0.2$
$\dot{q} = 10$ $\ddot{q} = 0$
$\dot{\phi}_1 = -11.3$ $\ddot{\phi}_1 = -200$
$\dot{\phi}_2 = 68.1$ $\ddot{\phi}_2 = 1750$

(b) Driving torque T_1 - V.W. eqn

$v_{G1} = \omega_1 \times \frac{AB}{2} = 10 k \times 1.7(0.966 i + .259 j)$
$= -4.40 i + 16.42 j$ cm/s

$v_{G2} = v_D = v_C + v_{D/C} = -68.1 i + 11.3(3.72) i$
$= -26.1 i$ cm/s

$v_{G3} = -68.1 i$ cm/s

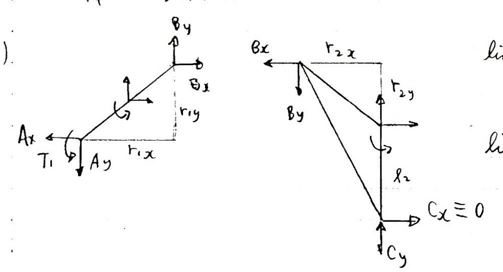
Principle of Virtual Work $\sum T \cdot \omega + \sum F \cdot v = 0$

$T_1(10) + (0.002)(-11.3) + (.166 i + .045 j) \cdot (-4.40 i + 16.42 j) \times 10^{-2}$
$+ 10^{-2} [(2.01 i + 0.95 j) \cdot (-26.1 i) + 3.5 i \cdot (-68.1) i] = 0$

$10 T_1 + 10^{-2}[-22.6 - 0.73 + 0.74 - 52.5 - 238.35] = 0$

$T_1 = 0.313$ Nm

(c)



Procedure

link 1 $\sum M_A = 0$	B_x B_y	
2 $\sum M_C = 0$	B_x B_y	
link 2 $\sum F = 0$	A_x A_y	
1 $\sum F = 0$	C_y	