

FOR THE INVENTED SLIPER CRAWK THE FIXED ANGLE & DEPINES THE OFFISET BETWEEN THE SCIDER AND LINK 4. THIS RESOLTS IN A RELATION SHIP BETWEEN G3 AND G4

NOTE THAT I'S A CONSTANT. THE LOCP THAT DEFINES THE RINEMATICS OF THIS PROBLEM CAN BE WILLIEW.

$$\vec{\Gamma}_{z} + \vec{\Gamma}_{\bar{s}} = \vec{\Gamma}_{\bar{s}} + \vec{\Gamma}_{\bar{q}}$$

$$\vec{\Gamma}_{z} = \Gamma_{z} \cdot \hat{C}_{rz} \ (= \alpha \cdot \hat{C}_{rz}) = \Gamma_{z} (\cos \theta_{z} \hat{c} + \sin \theta_{z} \hat{s})$$

$$\vec{\Gamma}_{\bar{s}} = \Gamma_{\bar{s}} \cdot \hat{C}_{rz} \ (= b \cdot \hat{C}_{rz}) = \Gamma_{\bar{s}} (\cos \theta_{\bar{s}} \hat{c} + \sin \theta_{\bar{s}} \hat{s})$$

$$\vec{\Gamma}_{\bar{s}} = \Gamma_{\bar{s}} \cdot \hat{C}_{rz} \ (= b \cdot \hat{C}_{r\bar{s}}) = \Gamma_{\bar{s}} (\cos \theta_{\bar{s}} \hat{c} + \sin \theta_{\bar{s}} \hat{s})$$

$$\vec{\Gamma}_{\bar{q}} = \mathcal{A} \cdot \hat{c}$$

$$\vec{\Gamma}_{\bar{q}} = \Gamma_{\bar{q}} \cdot \hat{C}_{r\bar{q}} \ (= c \cdot \hat{C}_{r\bar{q}} \ ) = \Gamma_{\bar{q}} \cdot (\cos \theta_{\bar{s}} \hat{c} + \sin \theta_{\bar{s}} \hat{s})$$

$$\vec{C}_{\bar{s}} = \hat{C}_{\bar{s}} \cdot \hat{C}_{r\bar{s}} \ (= c \cdot \hat{C}_{r\bar{q}} \ ) = \hat{C}_{\bar{q}} \cdot (\cos \theta_{\bar{s}} \hat{c} + \sin \theta_{\bar{s}} \hat{s})$$

THE LENGTH (3 = b HARJES AS THE LINKAGE MOVES. THUS (3 = b IS
A HARJABLE THAT MUST BE SOLDED FOR. THIS CREATES AN ADDITIONAL
UNKNOWN THAT NEEDS TO BE DETERMINED, O4, O5, G=b. HOWEVER, ① IS A
THIRD EQUATION THAT CAN BE USED TO DETERMINE THESE VANIABLES GIVEN OZ, a, c, d.

22-142 100 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

CAWPAD"

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STARTING WITH THE LOOP EQUATION (2) AND SUBSTITUTING (3)-6
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DOTTING WITH ?

12. cos Oz + 13. cos O3 = d + 14. cos O4

a: cos O2 + F3. cos O3 = d+ C. cos O4

8

DETENG WITH I

12. sin Oz+ 13. sin O3 = 14. sin O4

Q: sinOz+ [3. sin O3 = C. sin Oy

(9)

EQUATIONS (1), (8) G) ARE THREG EQUATIONS THAT CONTAIN THREE OWIENCEUR'S: (73; (03, (04), SOCHENG (9) FOR 13

F3 = C·sin Oq - a·sin Oz Sin O3

(10)

SUBSTITUTING (10) INTO (8)

 $a \cdot \cos \Theta_z + \left( \frac{C \cdot \sin \Theta_3 - a \cdot \sin \Theta_2}{\sin \Theta_3} \right) \cdot \cos \Theta_3 = d + C \cdot \cos \Theta_4$ 

a.cos02 + C.sin64cos03-a.sin62.cos03 - c.cos64 -d=0 1

SUBSTITUTING (1) INTO (11)

a.cosOz+ C.sinGy.cos(Oy-7)-a.sinGz.cos(Gy-7) - C.cosOy-d=0 Sin(Gy-9)

a.cos62+ C.sin64 (cos64 cos8+sin64.5+n8)-a.sin62 (cos64 cos8+sin64.5in8)
sin64 cos8 - cos64 sin8

- c. cos 64 - cl = 0

C.sin By.cosBy.cosB + C.sin By.sin By.sin B-a.sin Bz.cosBy.cosB-a.sin Bz.six By.six By

= C. cos 04 + d - a. cos 02

C. cos f. sin Oq. cos Oq + C. sin f. sin Oq = a. cos f. sin Oz cos Oq - a. sin f. sin Oz sin Oq = (c. cos Oq + d-a. cos Oz). (sin Oq. cos f = cos Oq. sin f) C.cos P. Sin Oy.cos O4 + C.sin P. Sin O4 - a.cos P. Sin Oz.cos O4 - a.sin P. Sin O4 Sin O4 - a.cos O4. Sin O4. cos O4. cos O4. Sin O4. cos O4.

C. cost sinθy cosθ + C. sin f. sin² Θ q - a · cos f. sinθ 2 · cosθ q - a · sin f. sin θ 2 · sin Θ q - c · cosθ q· sinθ q· cos f + c · cos θ q· sin f - d · sinθ q· cos f + d · cos Θ q· sin f + a · cosθ q· sinθ q· cos f - a · cosθ q· cos θ q· sin f = 0

C.sin f. (sin204+cos204)-a. (sin02.cosf+sinf.cos02).cos04 +a. (cos 02.cosf-sin02.sinf).sin 04-d.cosf.sin 04+dsinf.cos04=0

C. sin \$ - a. sin (02+5). cos 64 + a. cos (02+5). sin 64 - d. cos 8. sin 64 + d. sin 8. cos 64 = 0

[a·cos(Oz+))-d·cos]·sinO4+[-a·sin(Oz+)+d·sin]·cosO4+c·sin)=0

$$K_1 \cdot \sin \Theta_1 + K_2 \cdot \cos \Theta_1 + K_3 = 0$$

$$K_1 = \alpha \cdot \cos (\Theta_2 + \beta) - \alpha \cdot \cos \beta$$

$$K_2 = -\alpha \cdot \sin (\Theta_2 + \beta) + \alpha \cdot \sin \beta$$

$$K_3 = C \cdot \sin \beta$$

(12)

(13)

(74)

(15)

USING THE TRIGOMETRIC IDENTITIES

$$\sin 2\cdot d = \frac{2 \cdot \tan d}{1 + \tan^2 d} \Rightarrow \sin \theta = \frac{2 \cdot \tan \frac{\theta}{2}}{1 + \tan^2 \frac{\theta}{2}}$$

19

 $\cos 2 \cdot d = \frac{1 - \tan^2 d}{1 + \tan^2 d} \implies \cos \theta = \frac{1 - \tan^2 \frac{\theta}{2}}{1 + \tan^2 \frac{\theta}{2}}$ 

**(17)** 

SUBSTITUTING 16 AND 17 INTO 12

$$K_{1} \cdot \frac{2 \cdot \tan \frac{\Theta_{4}}{2}}{1 + \tan^{2} \frac{\Theta_{4}}{2}} + K_{2} \cdot \frac{1 - \tan^{2} \frac{\Theta_{4}}{2}}{1 + \tan^{2} \frac{\Theta_{4}}{2}} + K_{3} = 0$$

 $2 \cdot K_1 \cdot \tan^2 \theta + K_2 - K_2 \cdot \tan^2 \theta + K_3 + K_3 \cdot \tan^2 \theta = 0$  $(K_3 - K_2) \cdot \tan^2 \theta + 2 \cdot K_1 \cdot \tan \theta + (K_3 + K_2) = 0$ 

$$\tan^2 \frac{\Theta_4}{z} + \frac{2 \cdot K_1}{K_3 \cdot K_2} \cdot \tan \frac{\Theta_4}{z} + \frac{K_3 + K_2}{K_3 - K_2} = 0$$

$$\tan^{2} \frac{\Theta_{4}}{Z} + \frac{2 \cdot K_{4}}{K_{3} - K_{2}} \cdot \tan^{2} \frac{\Theta_{4}}{Z} + \left(\frac{K_{3}}{K_{3} - K_{2}}\right)^{2} - \left(\frac{K_{3}}{K_{3} - K_{2}}\right)^{2} + \frac{K_{3} + K_{2}}{K_{3} - K_{2}} = 0$$

$$\left(\tan^{2} \frac{\Theta_{4}}{Z} + \frac{K_{4}}{K_{3} - K_{2}}\right)^{2} = \left(\frac{K_{4}}{K_{3} - K_{2}}\right)^{2} - \left(\frac{K_{3} + K_{2}}{K_{3} - K_{2}}\right)$$

$$\tan^{2} \frac{\Theta_{4}}{Z} = -\frac{K_{4}}{K_{3} - K_{2}} + \sqrt{\left(\frac{K_{4}}{K_{5} - K_{2}}\right)^{2} - \left(\frac{K_{3} + K_{2}}{K_{3} - K_{2}}\right)}$$

$$\tan^{2} \frac{\Theta_{4}}{Z} = -\frac{K_{1}}{K_{3} - K_{2}} + \sqrt{\frac{K_{2}^{2} - \left(\frac{K_{3} + K_{2}}{K_{3} - K_{2}}\right)\left(\frac{K_{3} - K_{2}}{K_{3} - K_{2}}\right)}$$

$$\tan^{2} \frac{\Theta_{4}}{Z} = -\frac{K_{1}}{K_{5} - K_{2}} + \sqrt{\frac{K_{2}^{2} - \left(\frac{K_{3}^{2} + K_{2}}{K_{5} - K_{2}}\right)\left(\frac{K_{3} - K_{2}}{K_{3} - K_{2}}\right)}$$

$$\tan^{2} \frac{\Theta_{4}}{Z} = -\frac{K_{1}}{K_{5} - K_{2}} + \sqrt{\frac{K_{2}^{2} - \left(\frac{K_{3}^{2} - K_{2}}{K_{5} - K_{2}}\right)^{2}}{\left(\frac{K_{3} - K_{2}}{K_{3} - K_{2}}\right)^{2}}}$$

$$\tan^{2} \frac{\Theta_{4}}{Z} = -\frac{K_{1} \pm \sqrt{K_{1}^{2} + K_{2}^{2} - K_{3}^{2}}}{K_{3} - K_{2}}$$

$$\Theta_{4} = 2 \cdot \tan^{2} \left[-\frac{K_{1} \pm \sqrt{K_{1}^{2} + K_{2}^{2} - K_{3}^{2}}}{K_{3} - K_{2}}\right]$$

$$\Theta_{4} = 2 \cdot \tan^{2} \left[-\frac{K_{1} \pm \sqrt{K_{1}^{2} + K_{2}^{2} - K_{3}^{2}}}{K_{3} - K_{2}}\right]$$

$$(18)$$

THE SOLUTION OF THE INVERTED SLIDER CRANK LINKAGE STARTS WITH THE DEFINATION OF THE LINKAGE PARAMETERS

GIVEN: a, c, d, O2, d >

THE PARAMETERS THAT NEED TO BE DETERMINED INCLUDE

FIND: b, B3, & O4

THESE PARAMETERS ARE FECUND USING (1), (10), (13), (14), (13) AND (18)

THE VECTOR LOOP EQUATION FOR THE INVERTED SCIDER CRAWIS CAN BE WRITTEN

(19)

WHERE

20

(2)

(25)

THE SOLUTION TO PINDING THE VELOCITY COMPONENTS OF THE INVENTED SCIDER CRANK STARTS WITH TAKING THE DERIVATIVE OF (19) WITH RESPECT TO TIME.

12. êrz + 12. êrz + 13. êr3 + 13. êr3 = 12. êr4 + 14. êr4 + 14. êr4 Địể xêrz Địể xêr3 Địể xêr3 Địể xêr3

17. 02. 602+ 13. 613+13 03. 603 = 1404. 604

(26)

THE UNKNOWNS IN EQUATION 26 ARE \$3,\$\Text{O}\_1, AND \$\text{F}\_3.\$\Text{O}\_2 IS TYPICALLY GIVEN FOR A INVENTED SCIDEN CRANK LINKAGE. EQUATION 26 CAN ALSO BE REPRESENTED BY TWO SCACAN EQUATIONS. A THIRD EQUATION IS NEEDED TO SOLVE ALL THREE HELOCITY UNKNOWNS. THE THIRD EQUATION EQUATION IS POOND BY TAKING THE DERIVATIVE OF (1)

 $\dot{\Theta}_{4} = \dot{\Theta}_{3}$ 

27

SOBSTITUTING THE UNIT HECTORS 20 -(25) INTO (26)

(28)

DOTTENG (28) WATH ?

- F2. 02. Sin 02 + F3. COS 03 + F3. 03. SIN 03 = F4. 04. Sin 04

12. Oz sin Oz - 13. cosO3 + 5. O3. sin O3 = 14. O4. sin O4

(29)

DOTIONG (28) WETH I

12. 02. cos 02 + 13. 5in 03 + 13. 03. cos 03 = 14. 04. cos 04 39

SOLUTING (29) FOR (3

 $\frac{1}{3} = \frac{\Gamma_2 \cdot \dot{\Theta}_2 \cdot \sin \Theta_2 + \Gamma_3 \cdot \dot{\Theta}_3 \cdot \sin \Theta_3 - \Gamma_4 \cdot \dot{\Theta}_4 \cdot \sin \Theta_4}{\cos \Theta_3}$ 

(31)

SCBSTITUTING (3) IND (30)

 $\Gamma_{2} \cdot \dot{\Theta}_{2} \cdot \cos \Theta_{2} + \sin \Theta_{3} \cdot \frac{\Gamma_{2} \cdot \dot{\Theta}_{2} \cdot \sin \Theta_{2} + \Gamma_{3} \cdot \dot{\Theta}_{3} \cdot \sin \Theta_{3} - \Gamma_{4} \cdot \dot{\Theta}_{4} \cdot \sin \Theta_{4}}{\cos \Theta_{3}}$   $+ \Gamma_{3} \cdot \dot{\Theta}_{3} \cdot \cos \Theta_{3} = \Gamma_{4} \cdot \dot{\Theta}_{4} \cdot \cos \Theta_{4}$ 

12. 02. cos 02. cos 03 + 12. 02. sin 02. sin 03 + 13. 03. sin 03. sin 03. sin 04. sin 03. sin 04. cos 04. cos 03

1. 02 cos (02-03) + 13.03 - 14.04 cos (04-03) =0

SUBSTITUTING (27) INTO THE ABOVE EQUATION

 $\dot{\Theta}_3 = -\frac{\Gamma_2 \cdot \dot{\Theta}_2 \cdot \cos(\Theta_2 - \Theta_3)}{\Gamma_3 - \Gamma_4 \cdot \cos(\Theta_4 - \Theta_3)}$ 

(32)