Computer Animation

Lesson 4 - Forward and inverse kinematics

Remi Ronfard, Nov 2019

Principle 4 Slow in & Slow out

Slow in and slow out deals with the spacing of the inbetween drawings between the extreme poses. Mathematically, the term refers to second- and third-order continuity of motion.

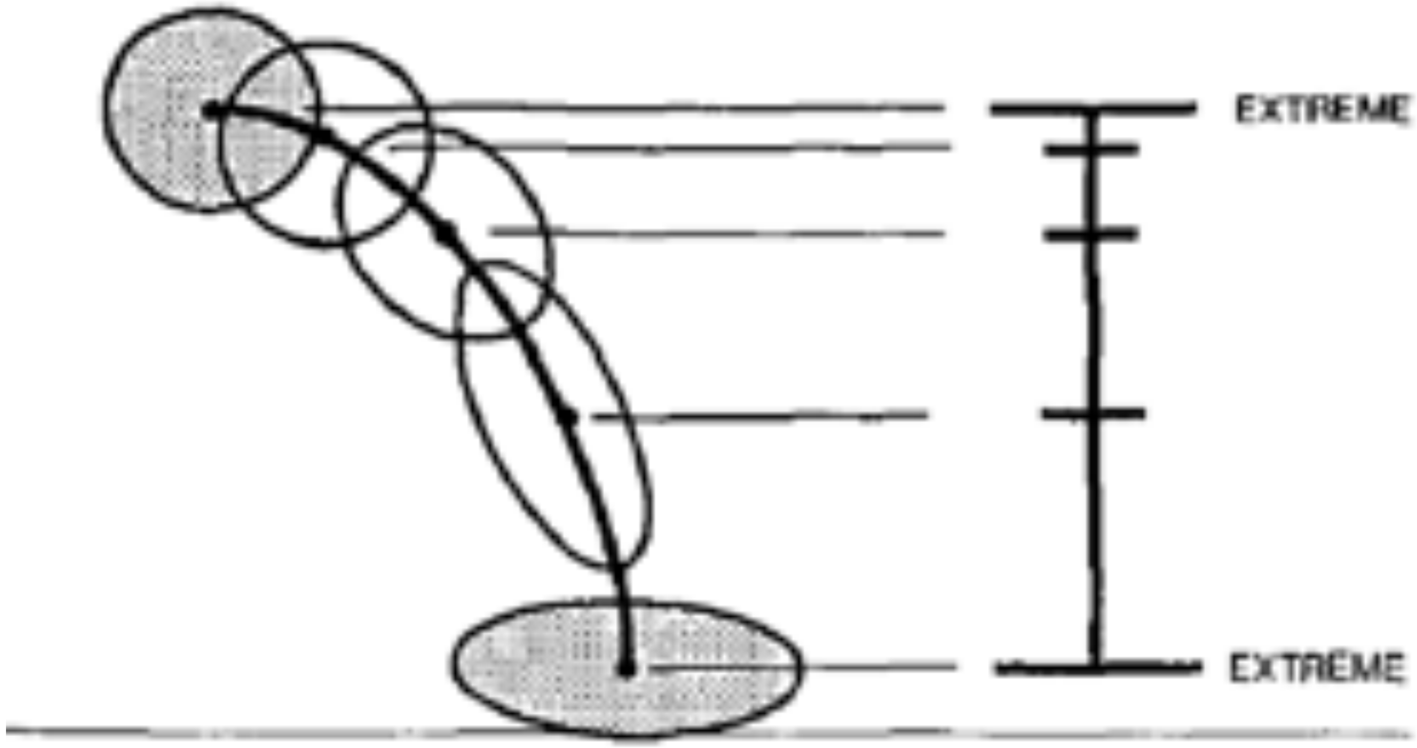
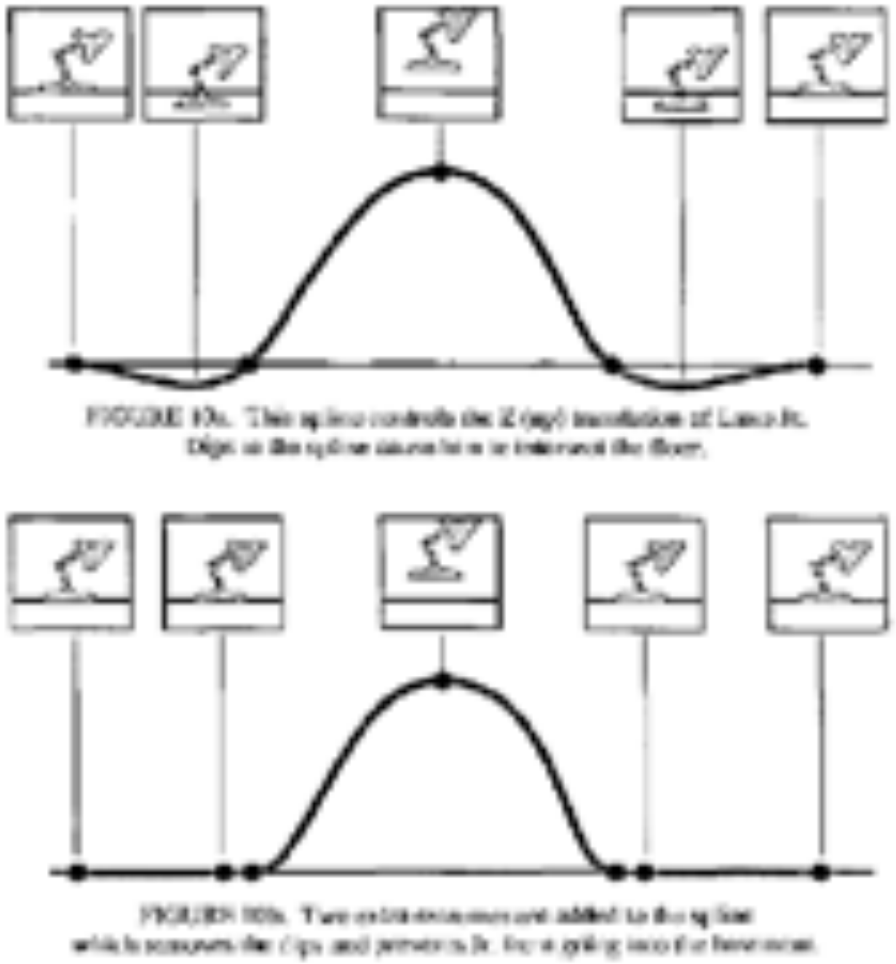


FIGURE 9. Timing chart for ball bounce.



6. Slow In & Slow Out

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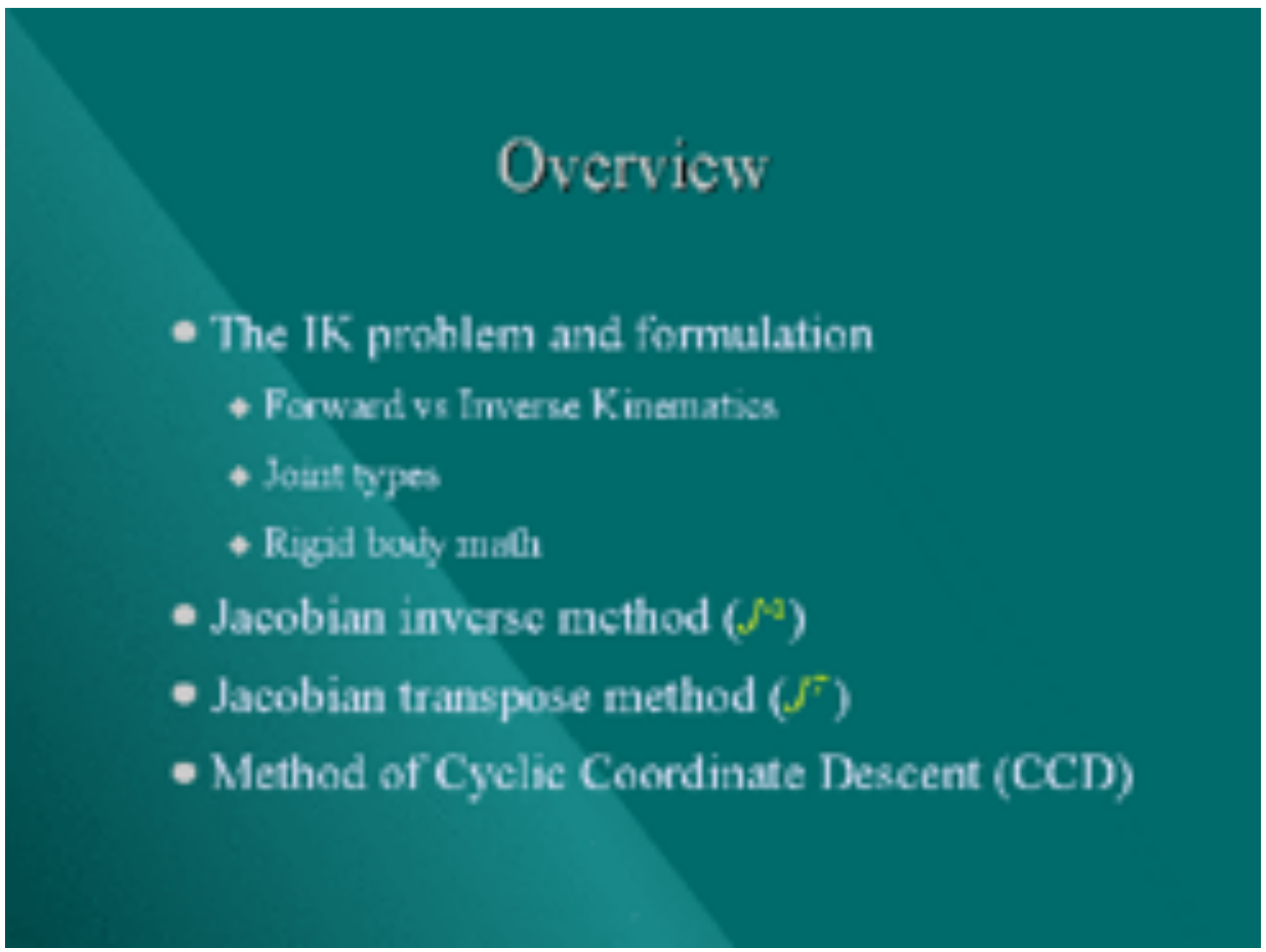

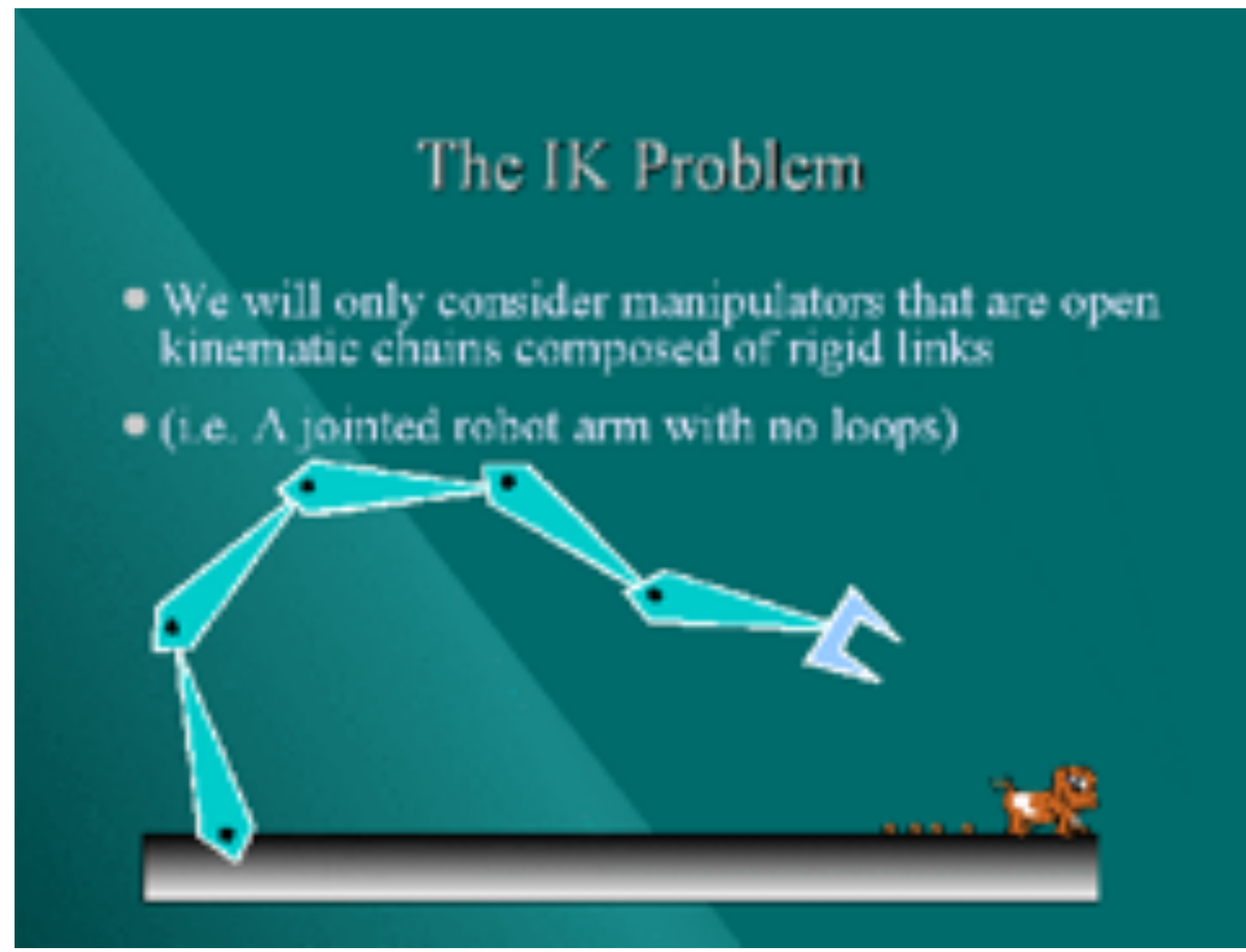

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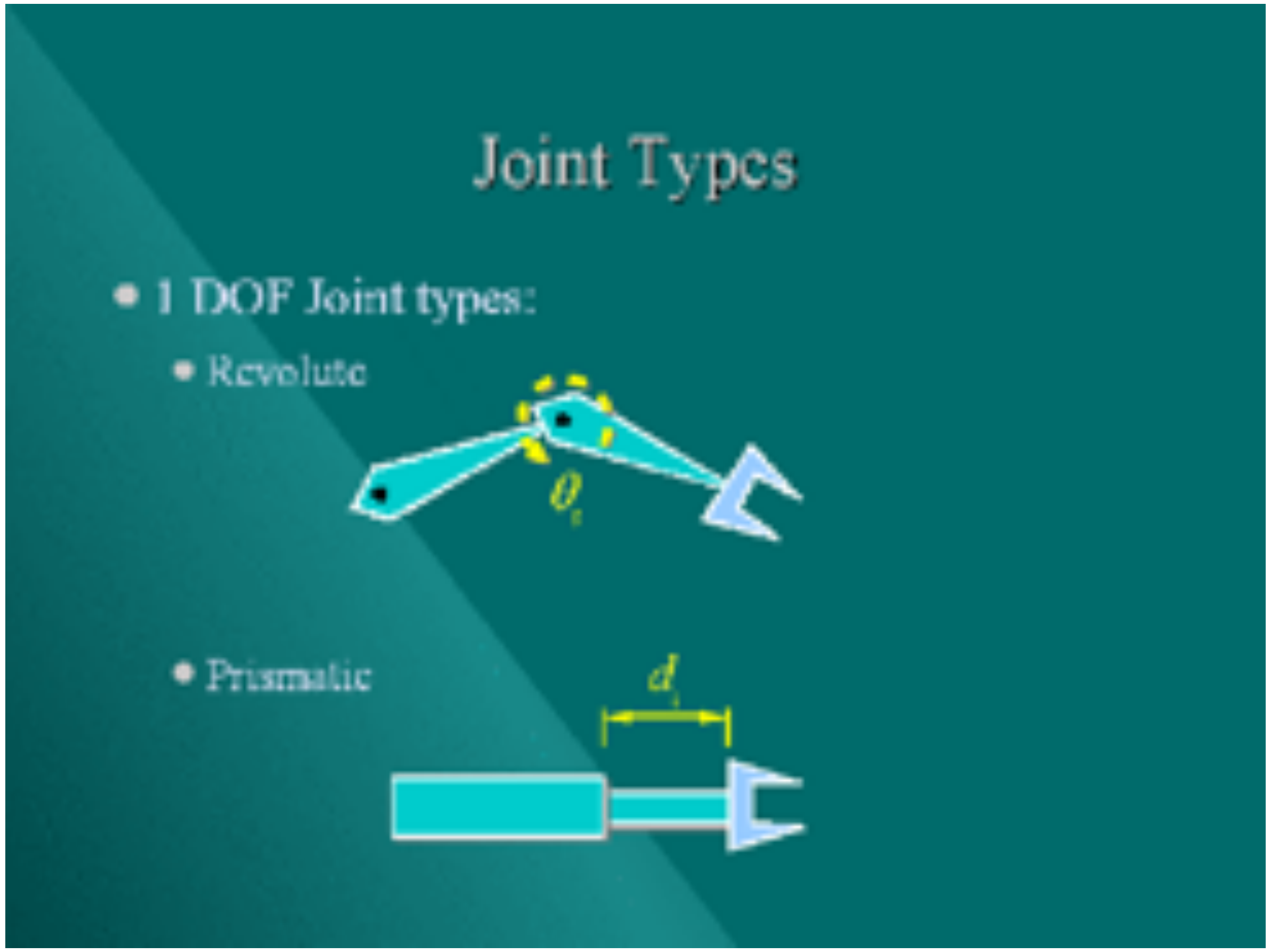

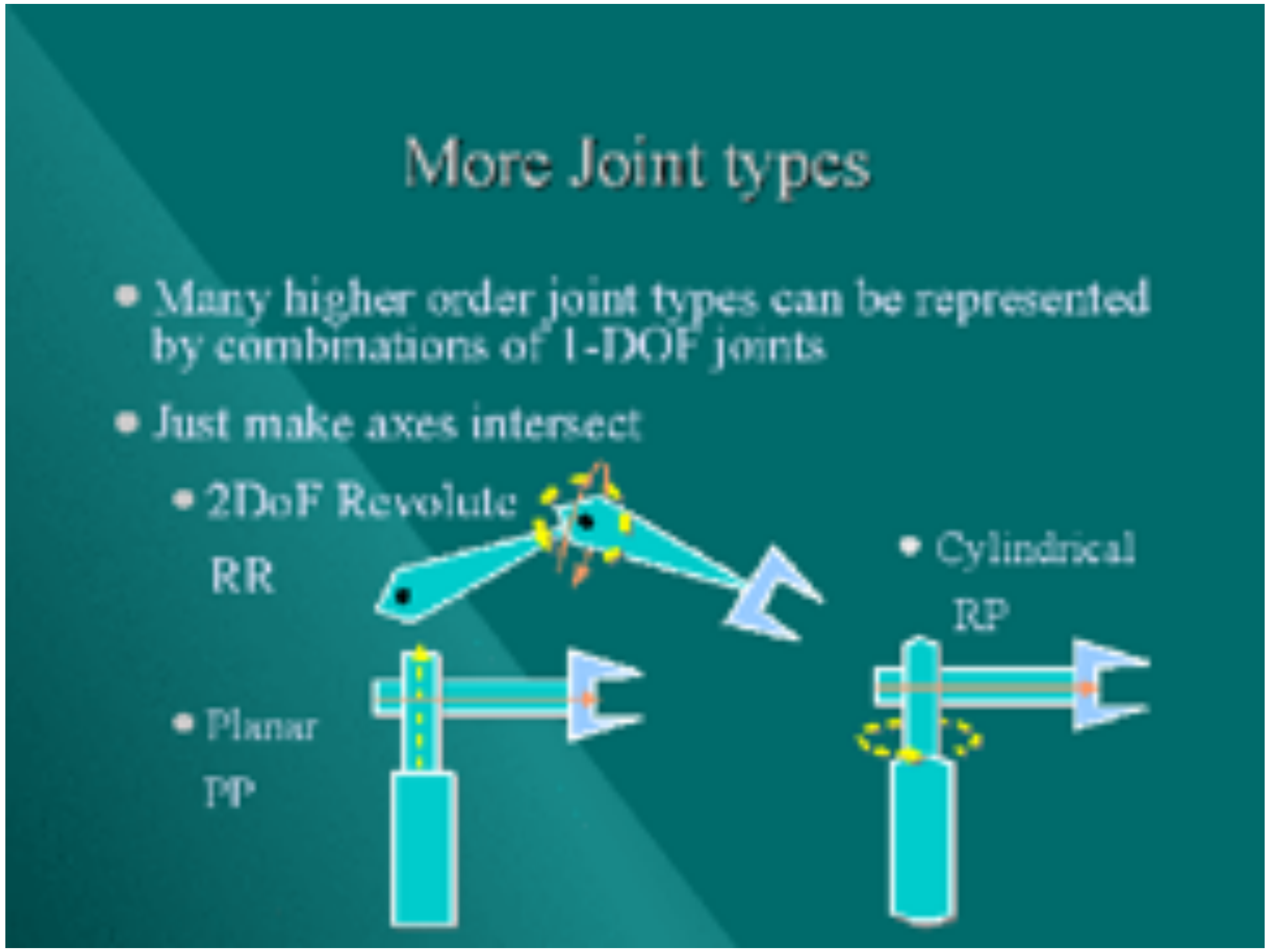

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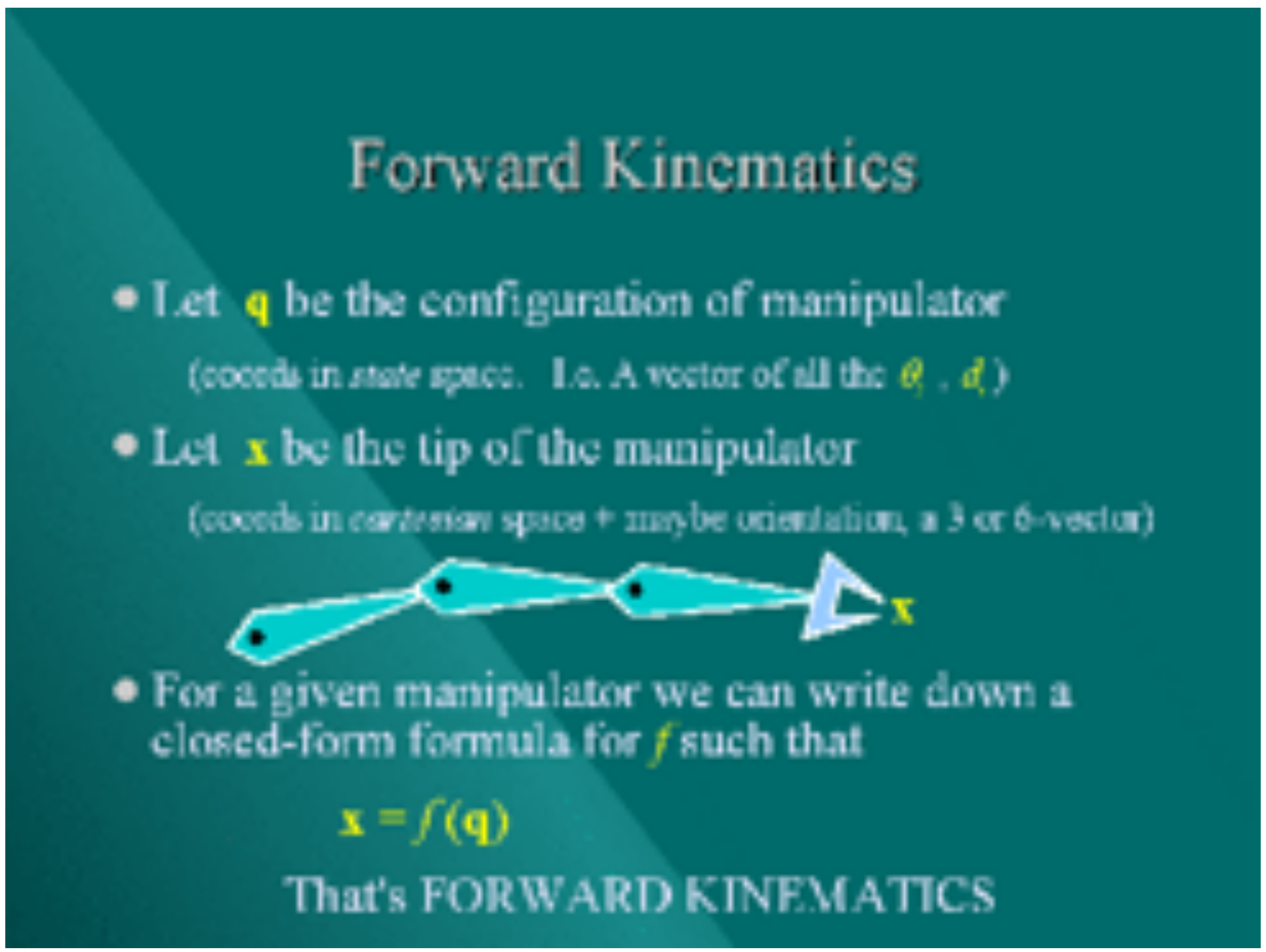

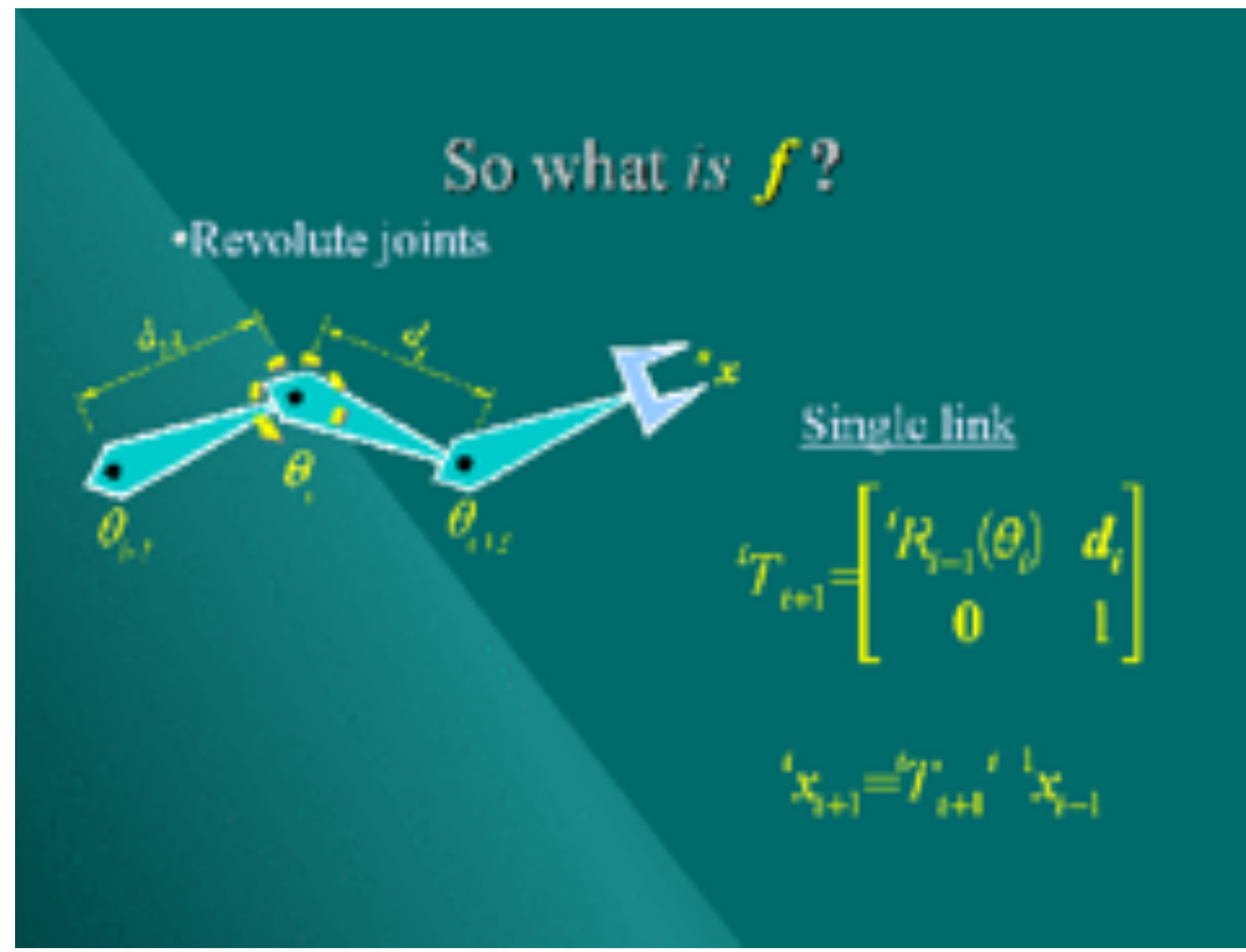

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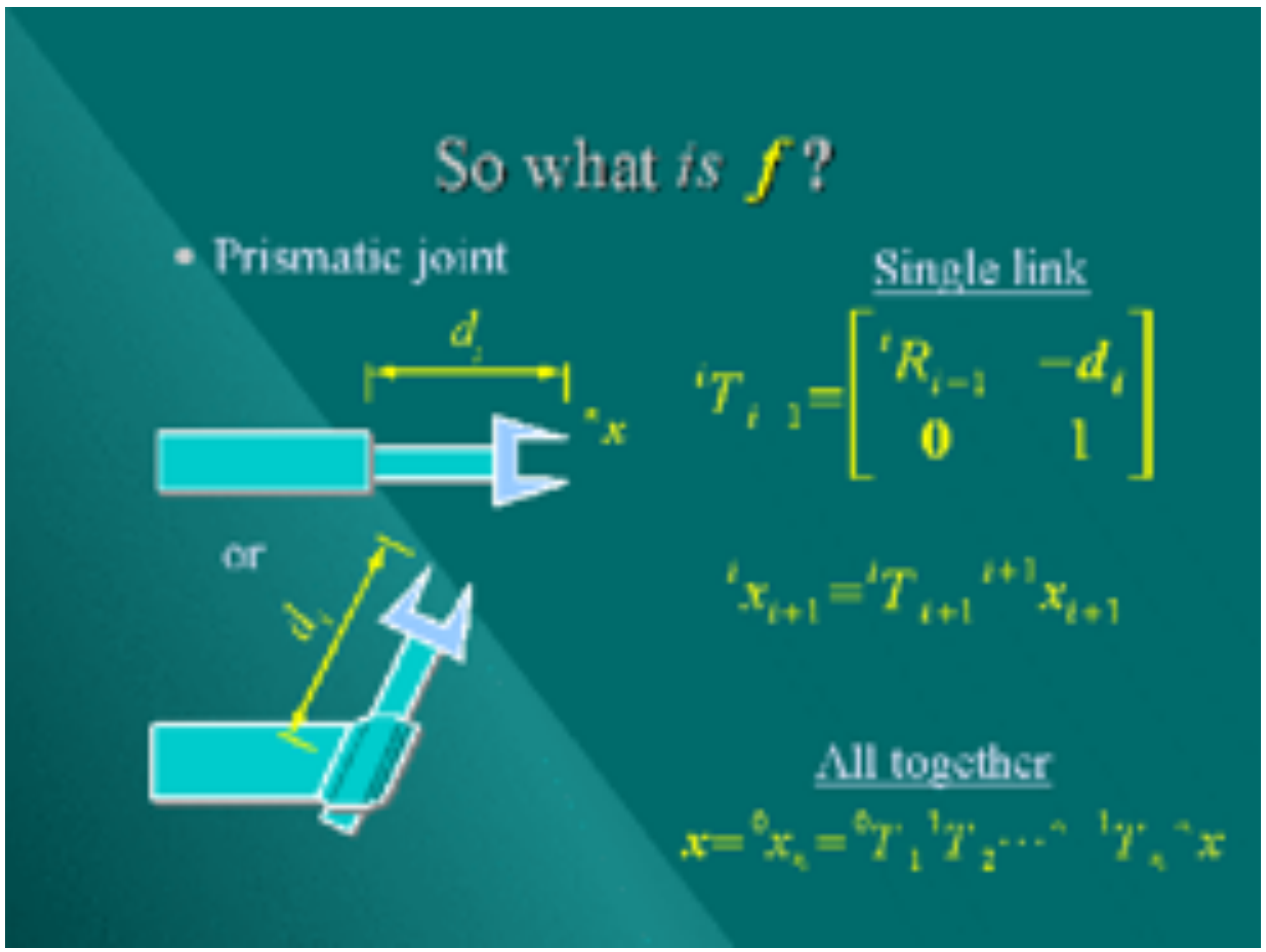

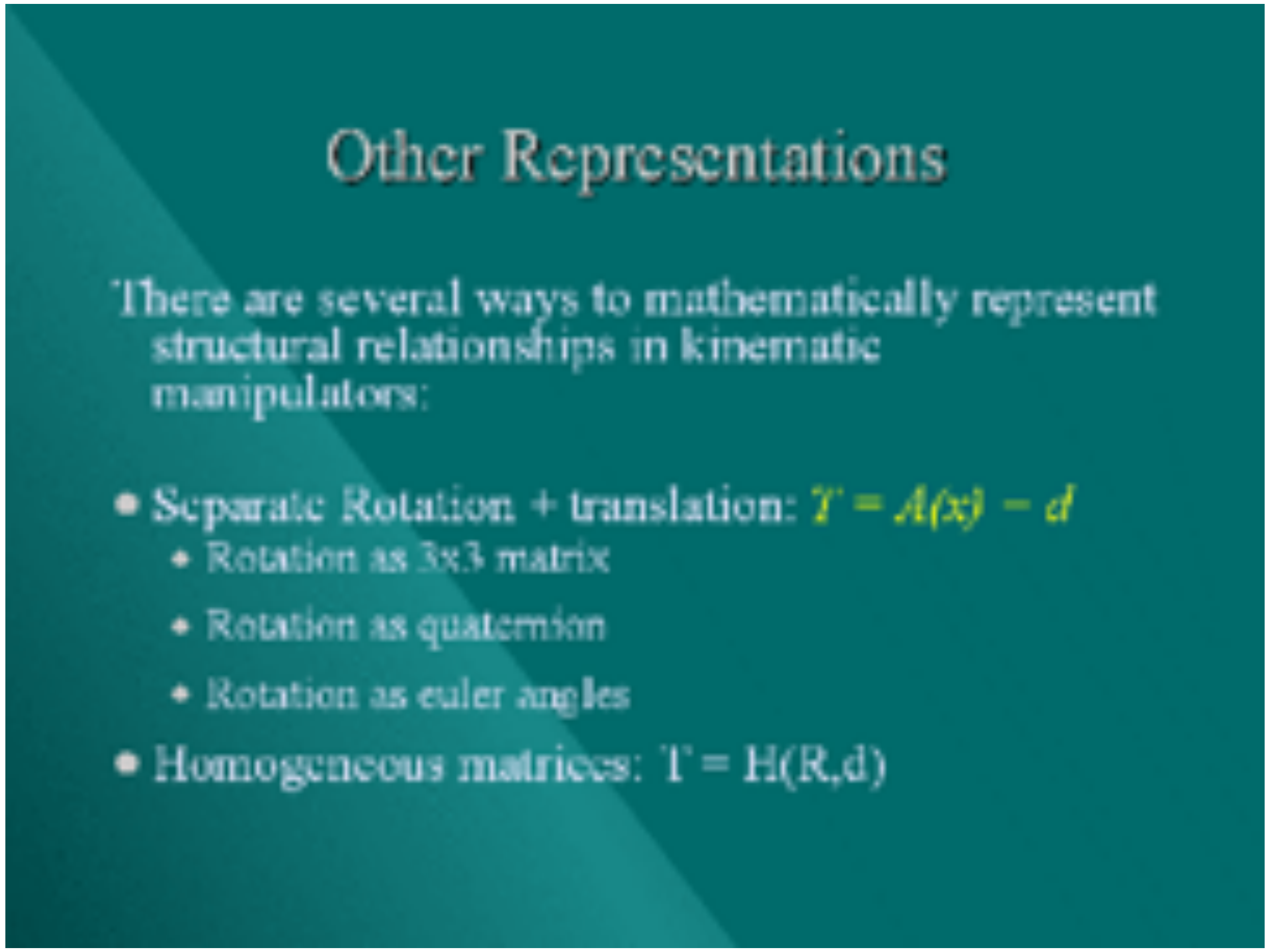

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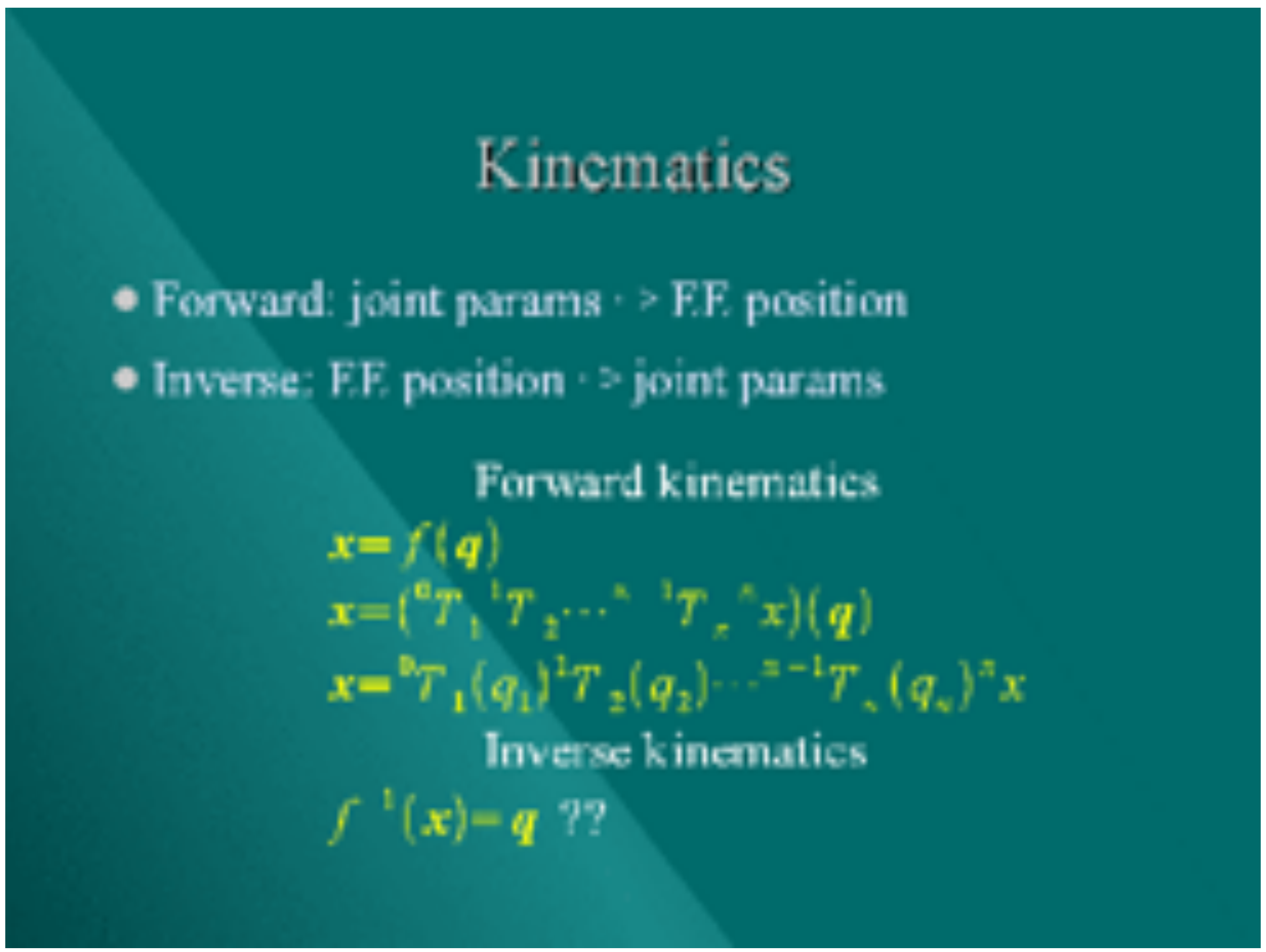

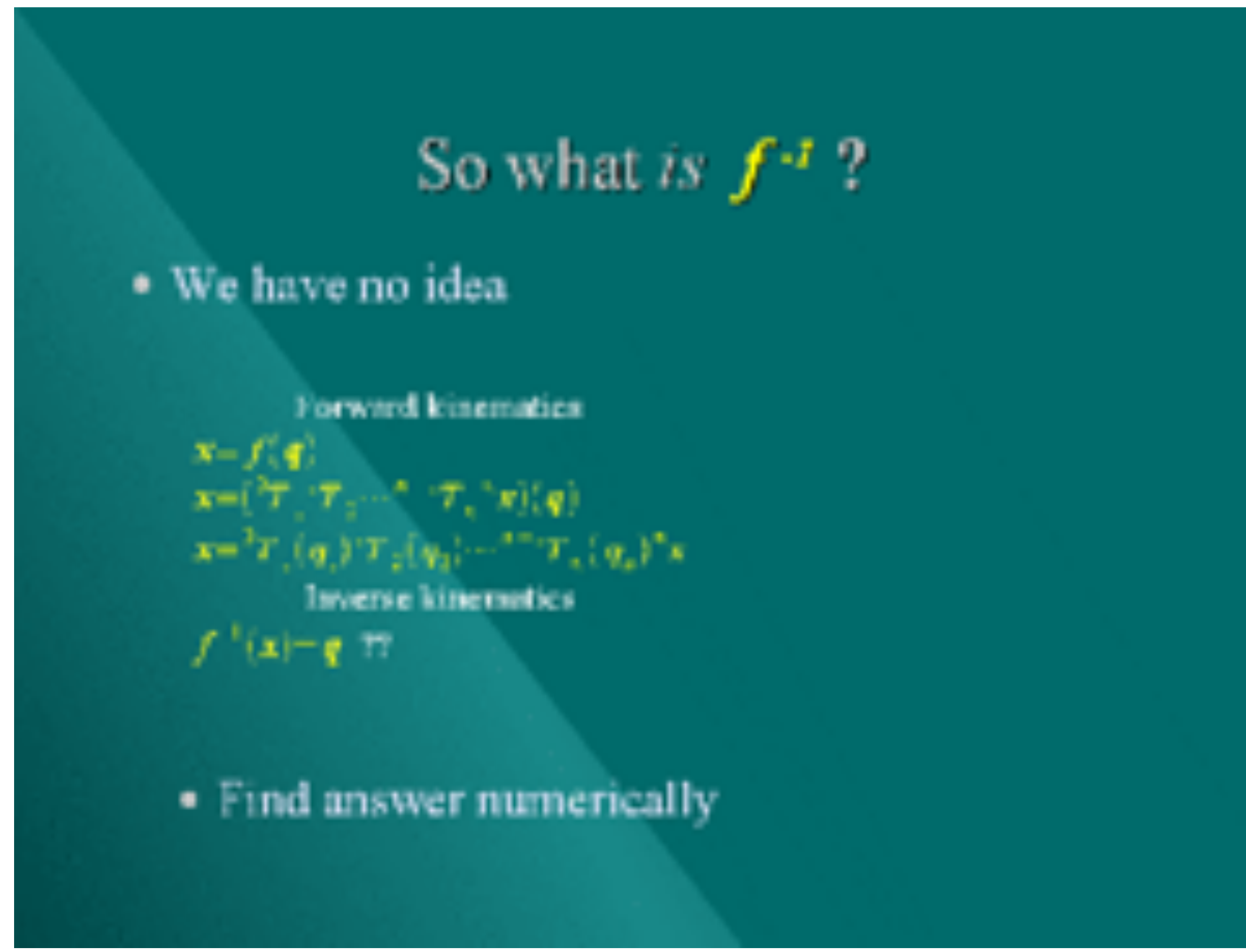

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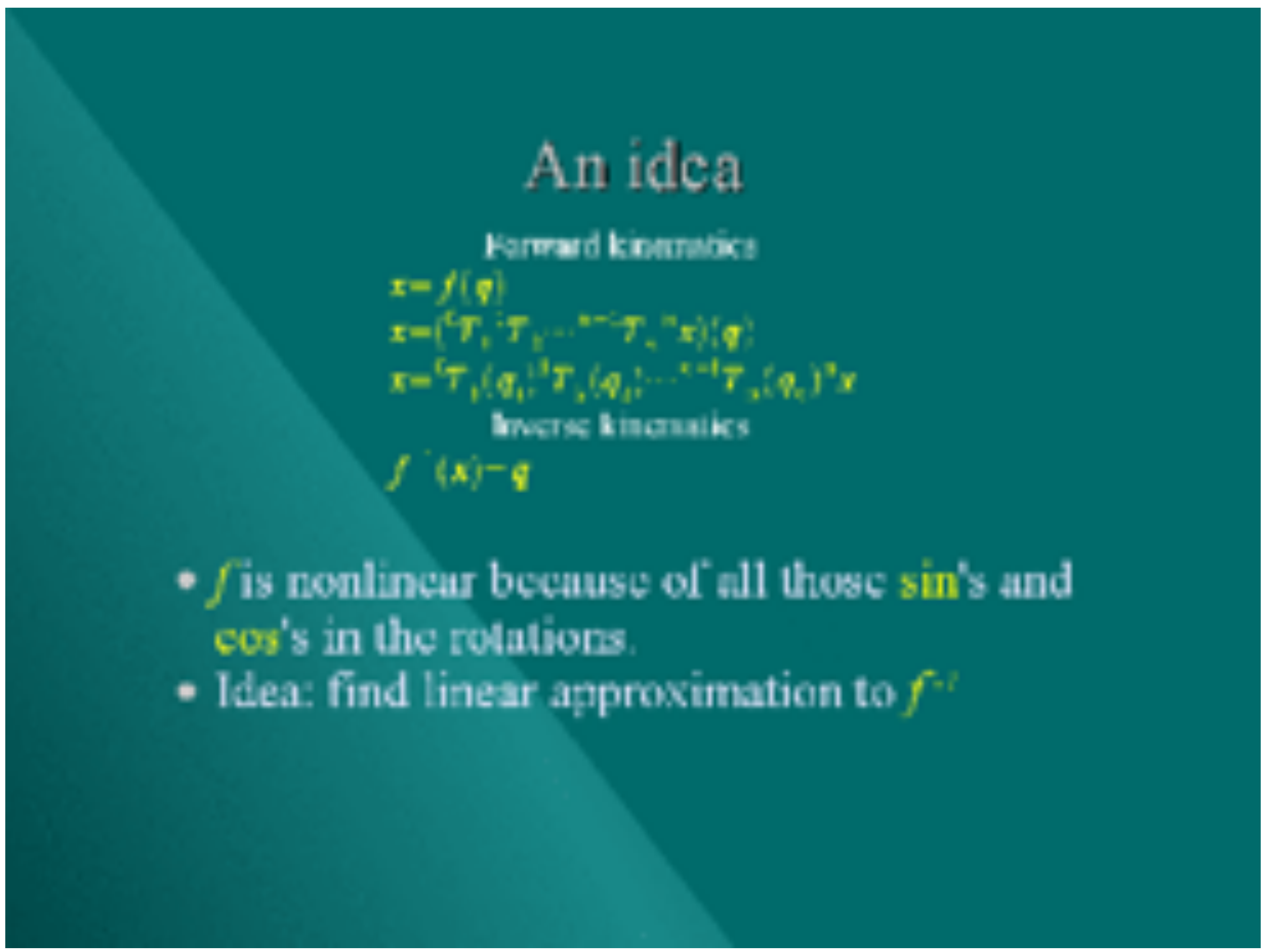

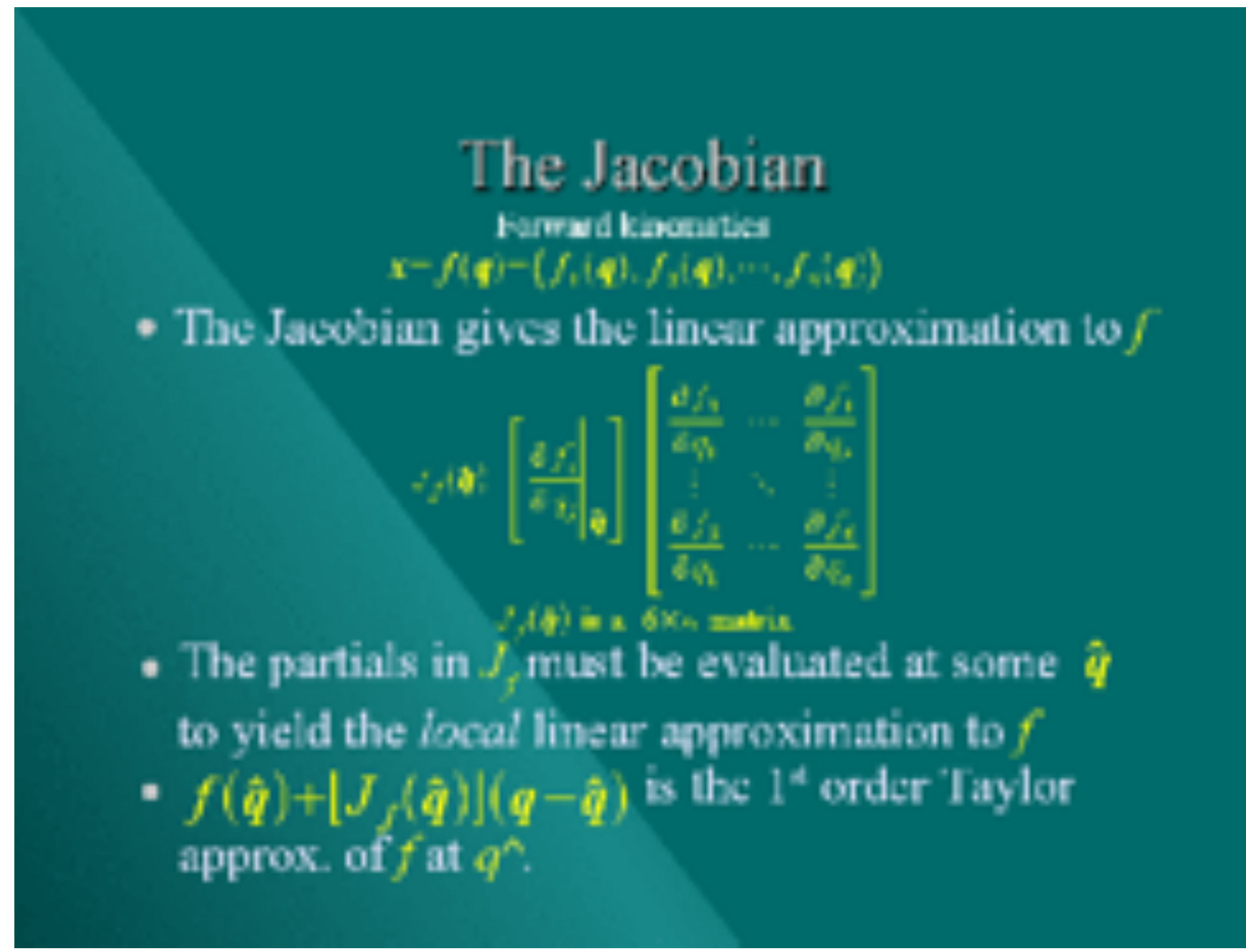

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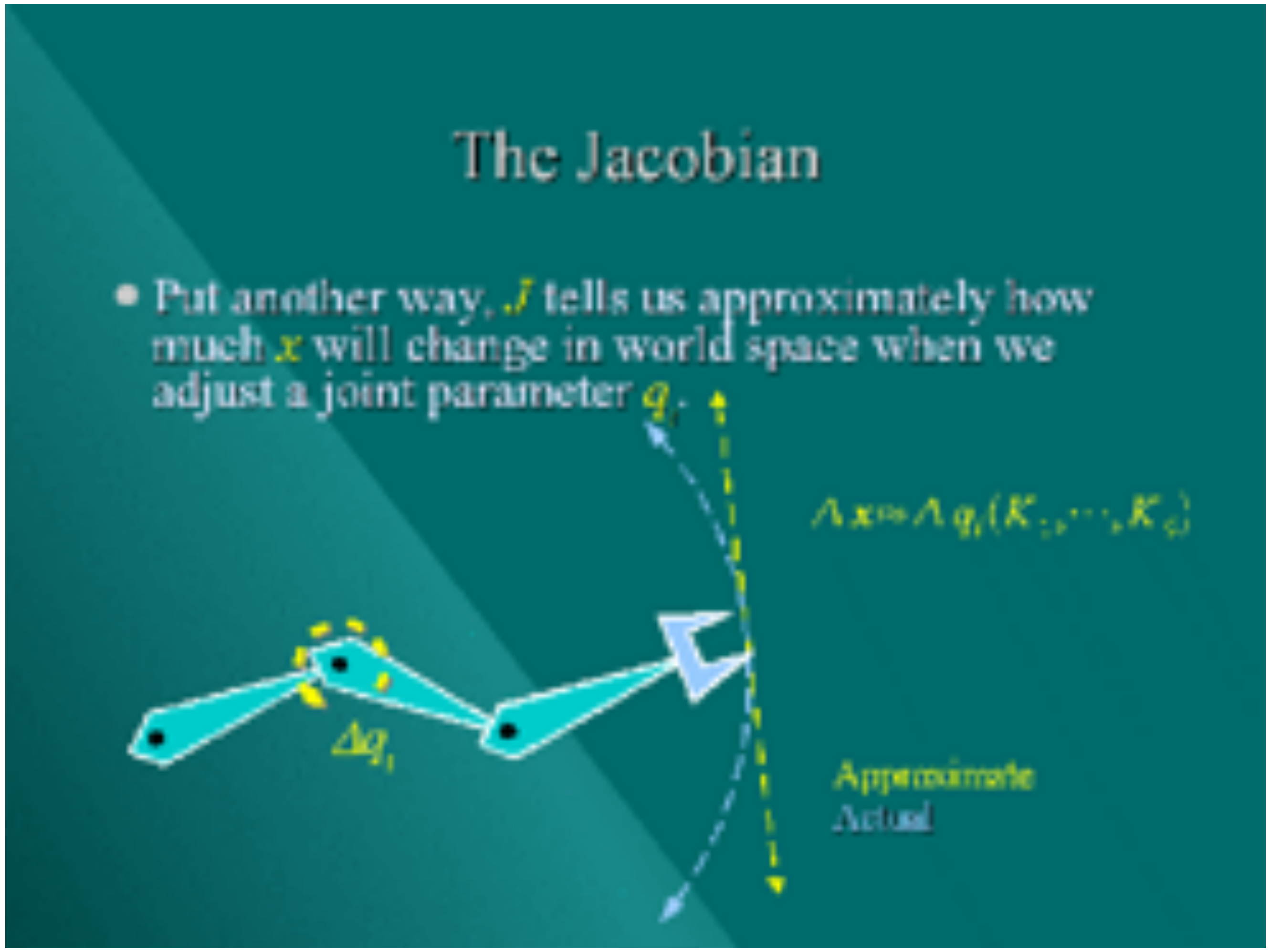

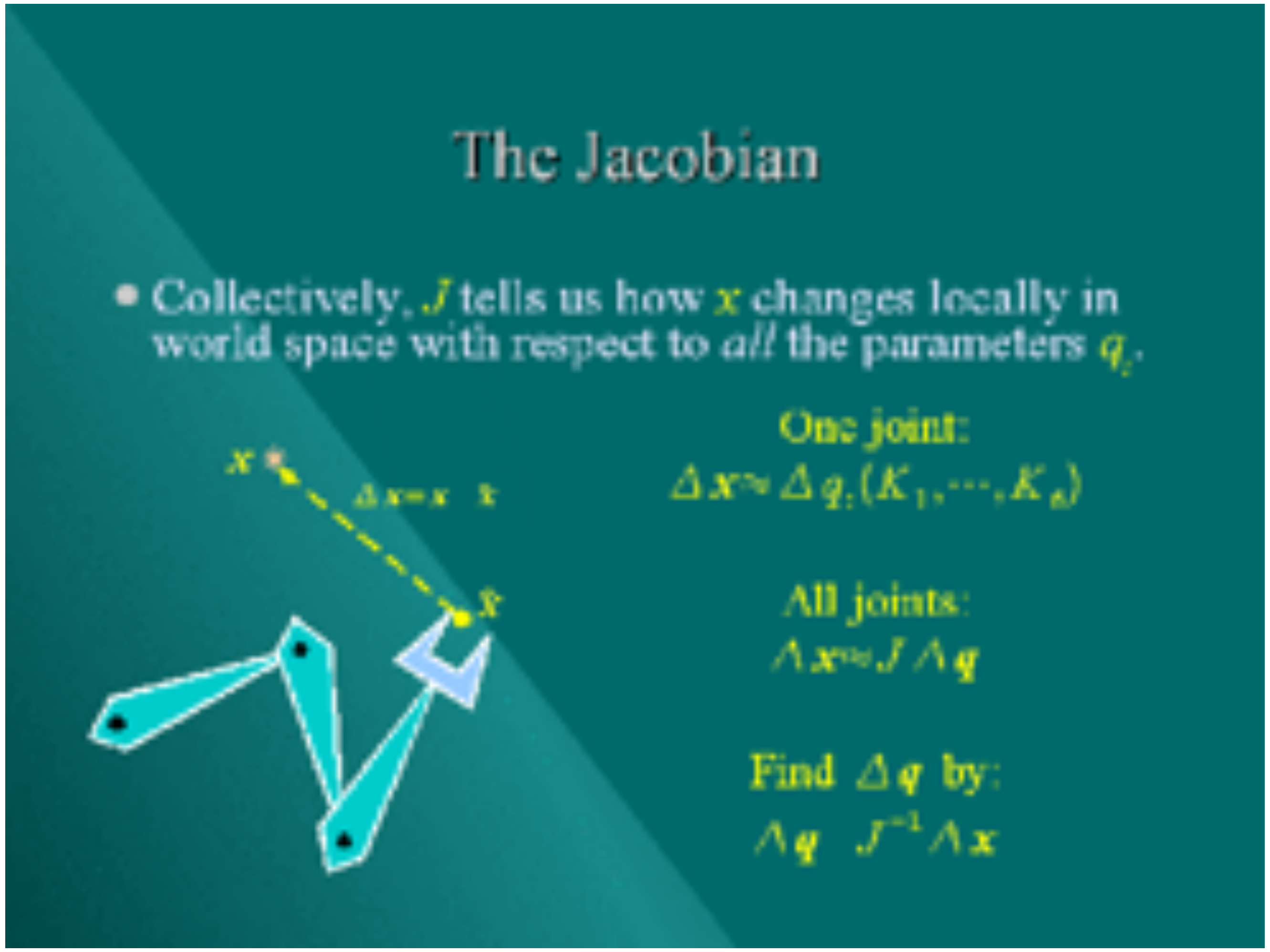

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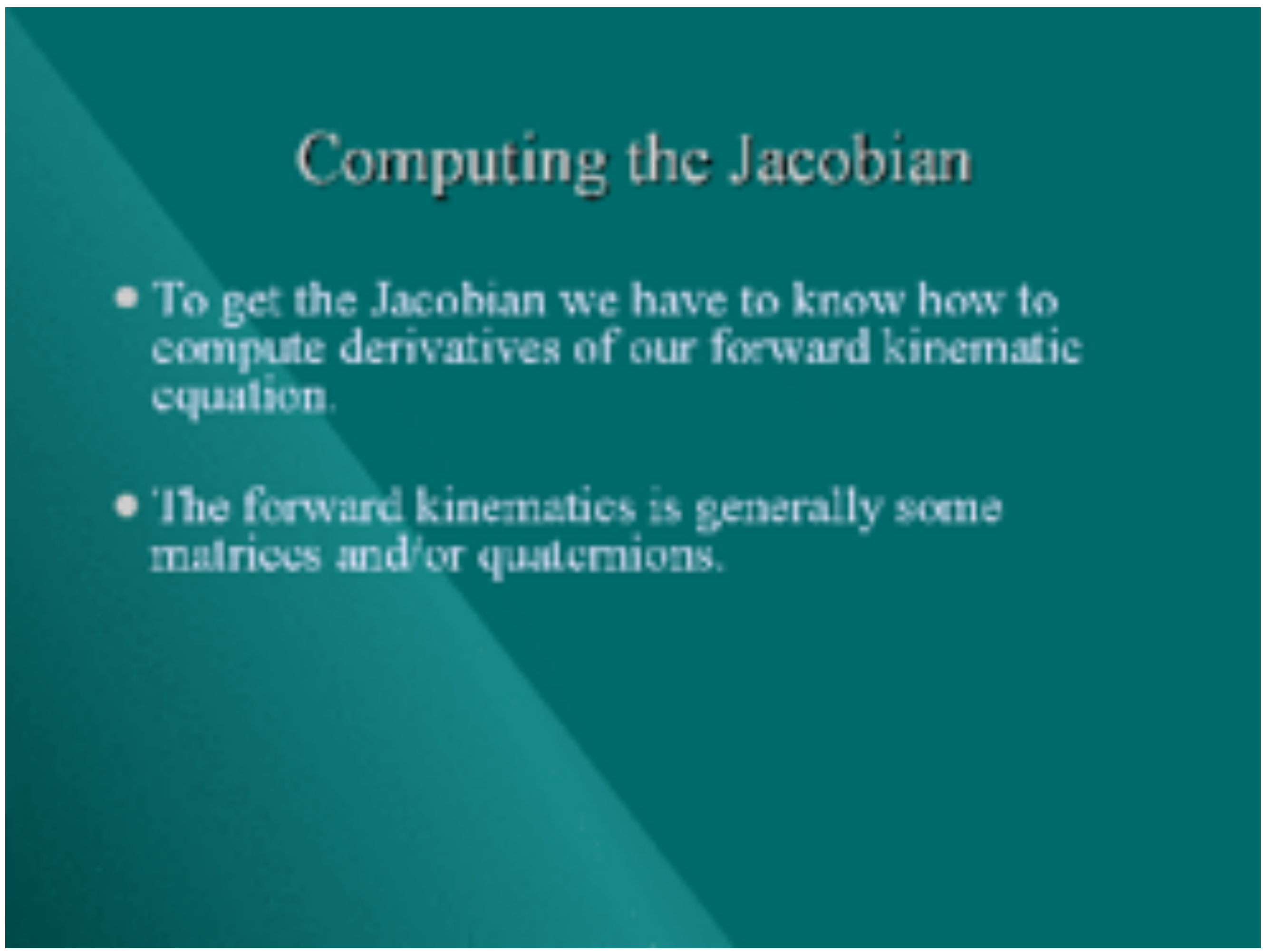

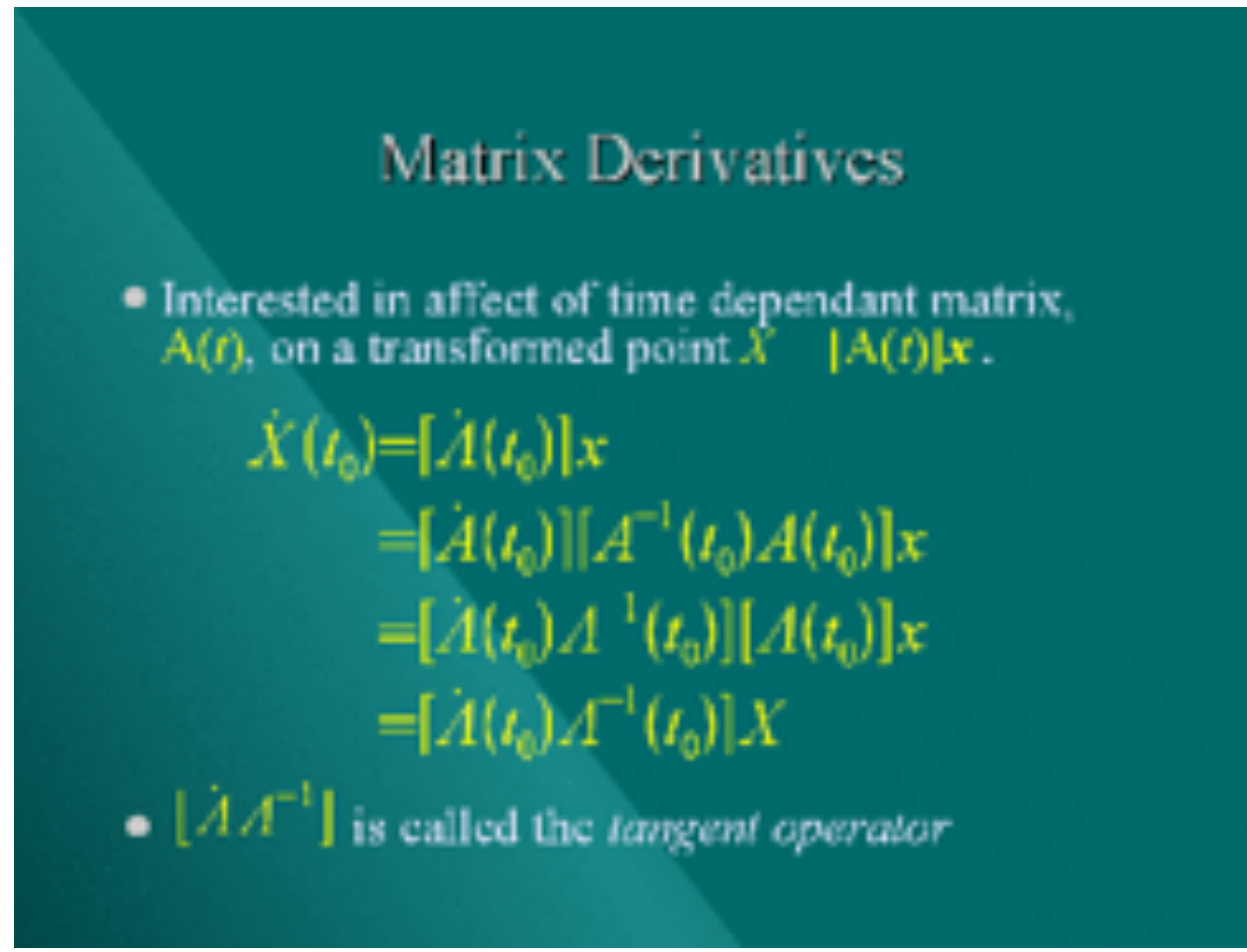

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Rotation Matrix Derivatives

- What's the tangent operator for a rotation?

$$RR^T = I \quad \text{(by orthonormality)}$$
$$\dot{R}R^T + R\dot{R}^T = 0 \quad \text{(from differentiation)}$$
$$\dot{R}R^T + (\dot{R}R^T)^T = 0$$
$$\dot{R}R^T = -(\dot{R}R^T)^T \quad \text{(skew symmetric)}$$
$$\dot{R}R^{-1} = \dot{R}R^T = \Omega \quad \text{(so tangent operator is skew symmetric)}$$

- Ω is the *angular velocity* matrix of $R(t)$

The Angular Velocity Matrix

- Ω is skew symmetric so it can be written

$$\Omega = \begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_x & 0 & -\omega_z \\ -\omega_y & \omega_x & 0 \end{bmatrix}$$

- And its effect on on a vector $\boldsymbol{r}$ is equivalent to the cross product with $\boldsymbol{\omega}$ $(\omega_x, \omega_y, \omega_z)$

$$\Omega \boldsymbol{r} \equiv \boldsymbol{\omega} \times \boldsymbol{r}$$

- $\boldsymbol{\omega}$ is the axis of the rotation, $\boldsymbol{\omega}$ is the amount.

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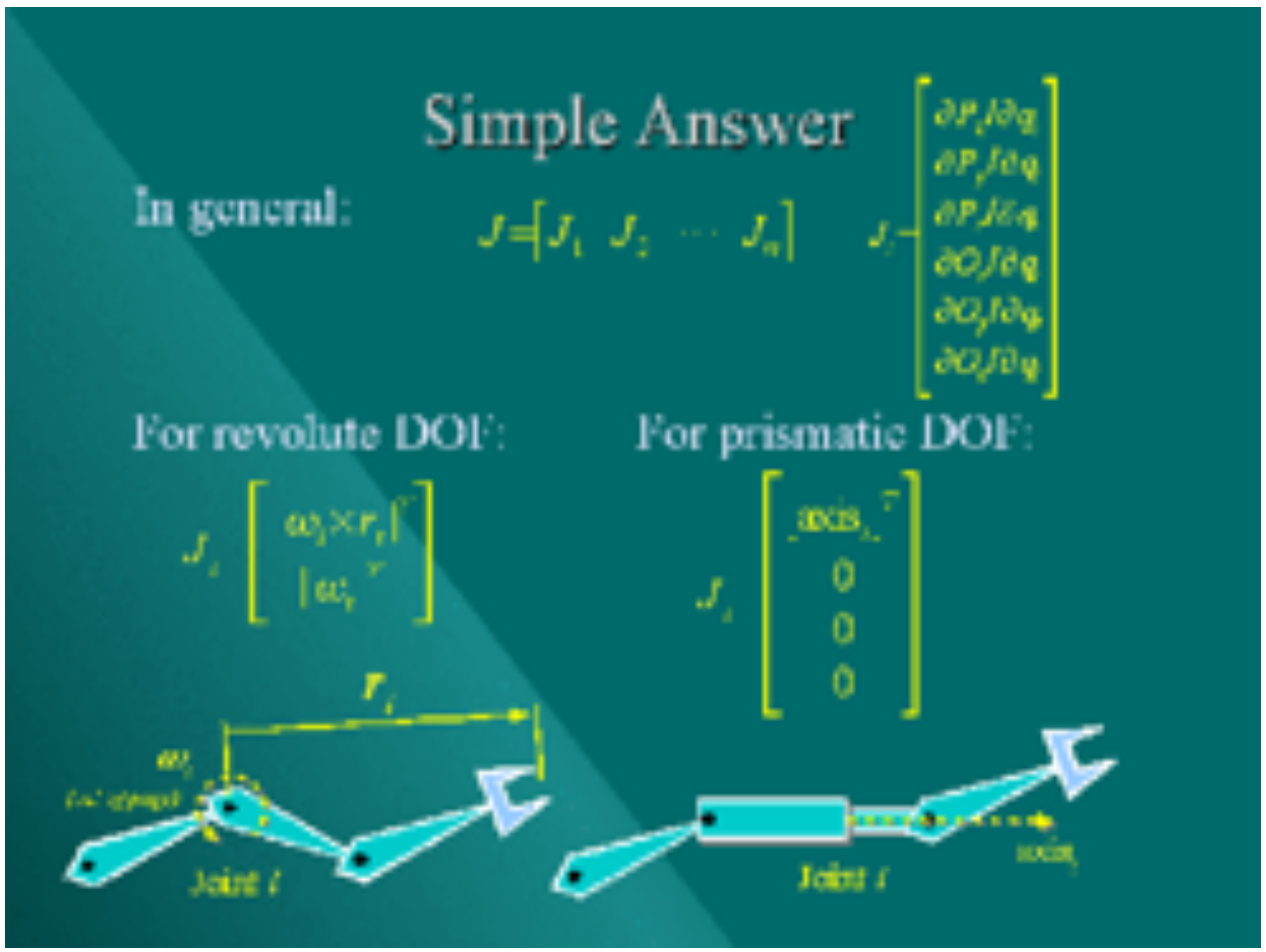

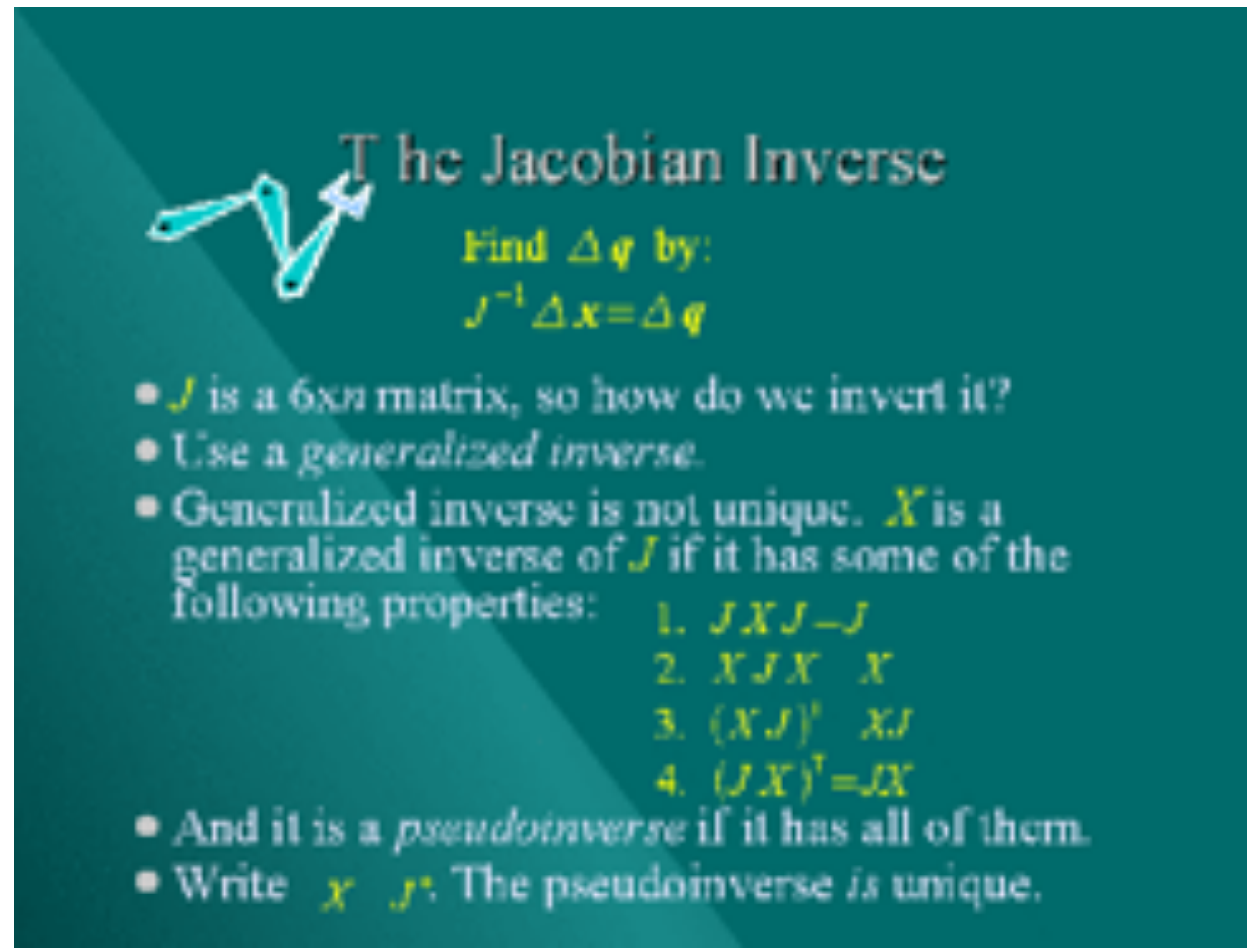

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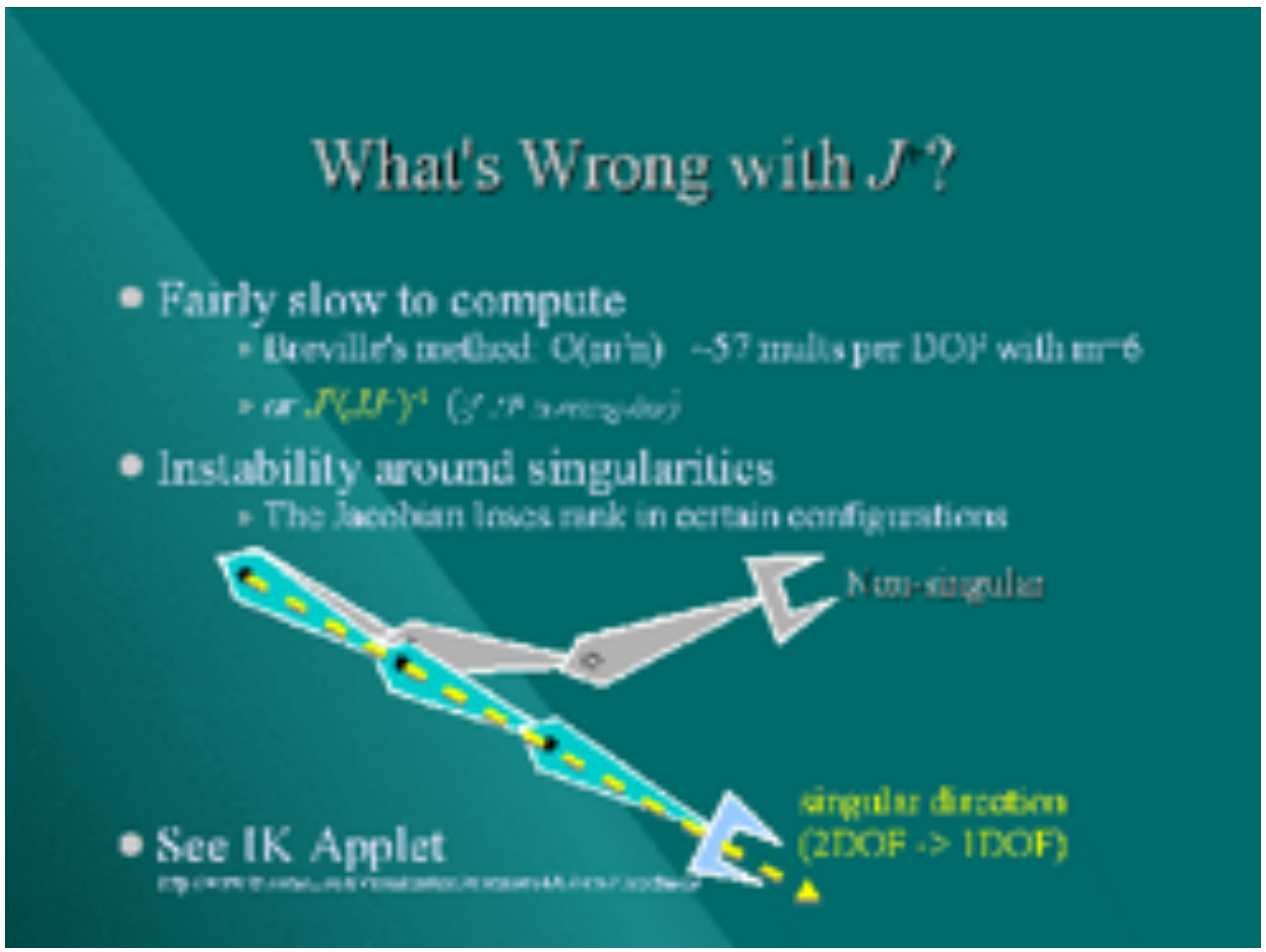

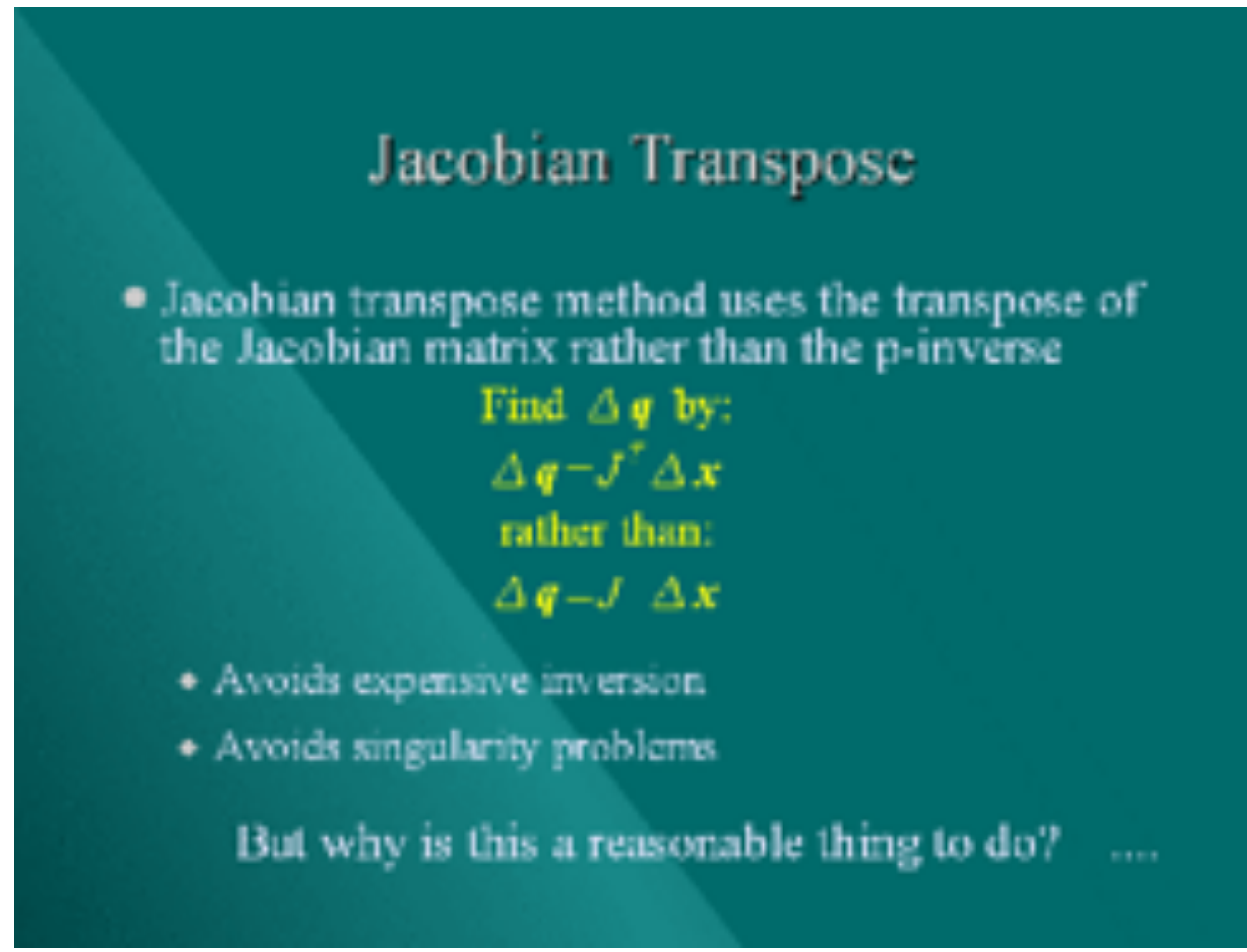

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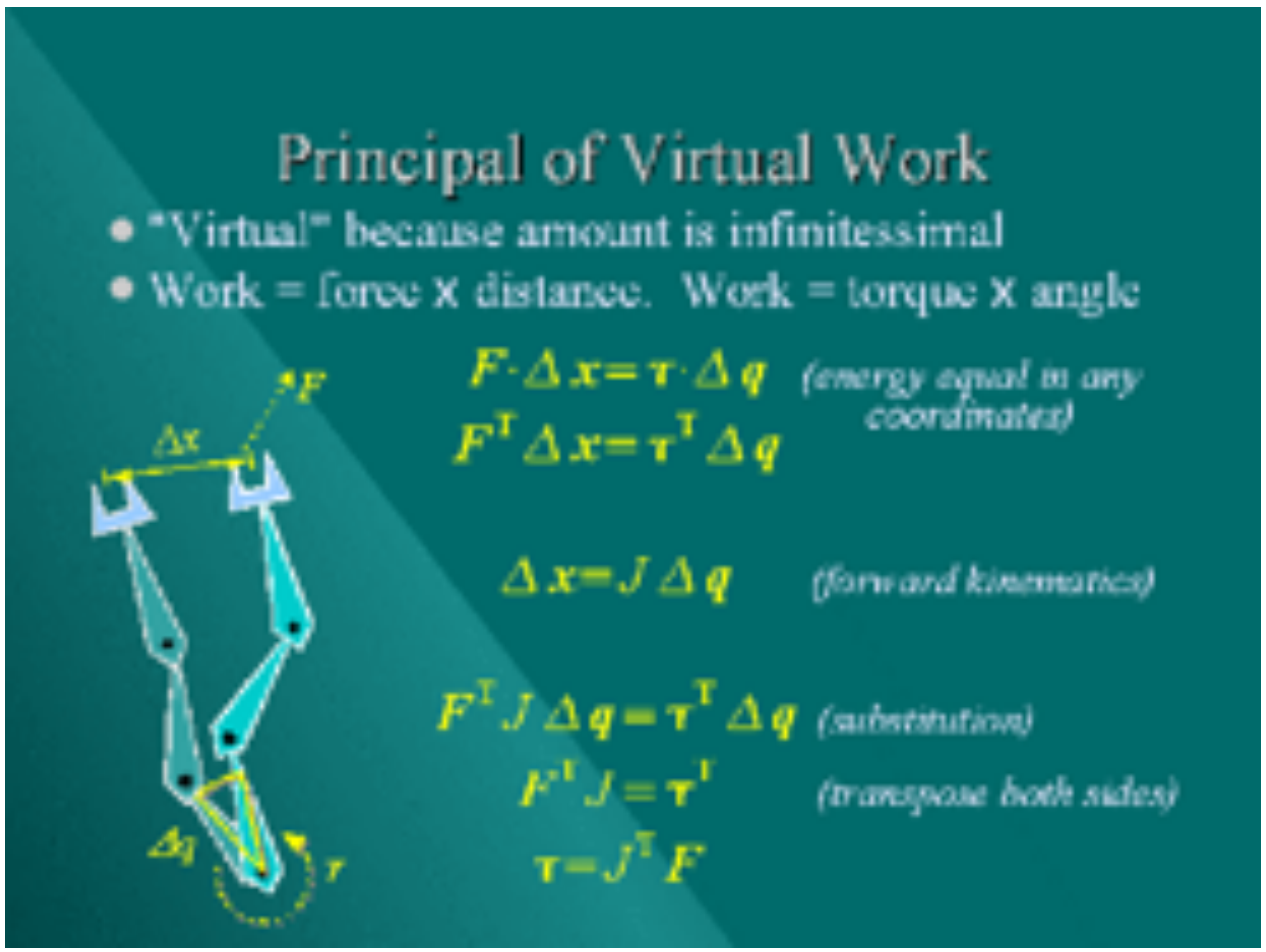

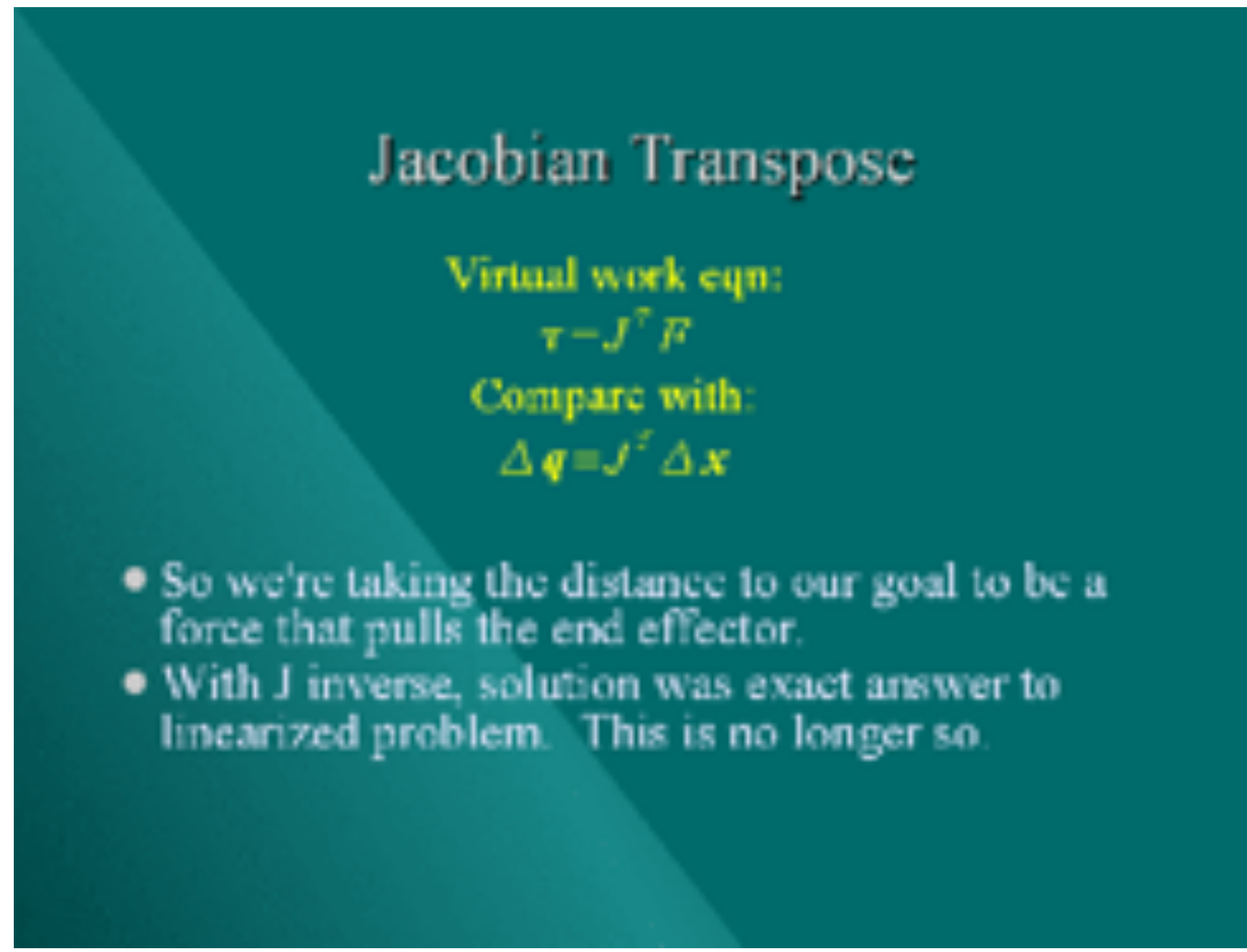

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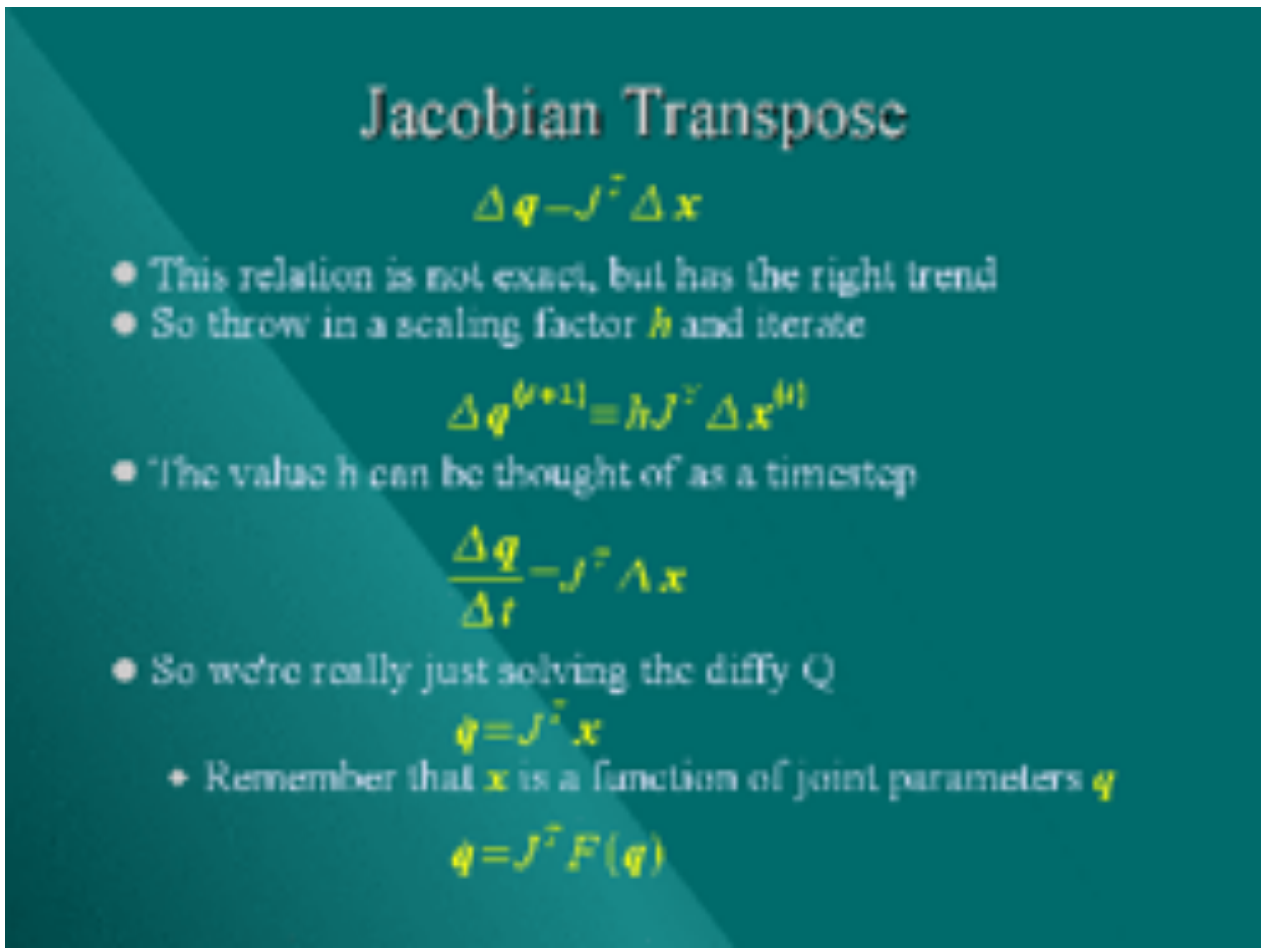

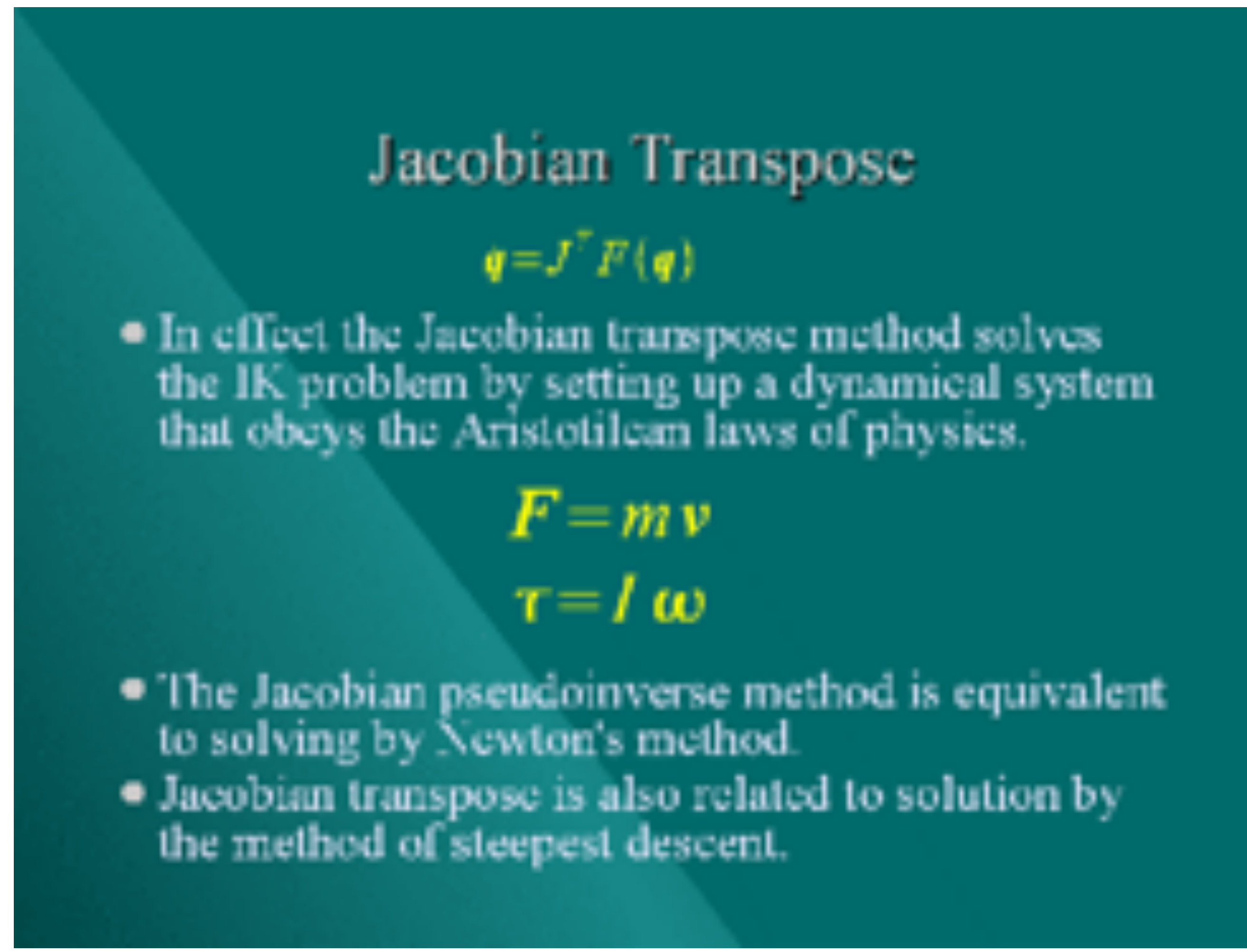

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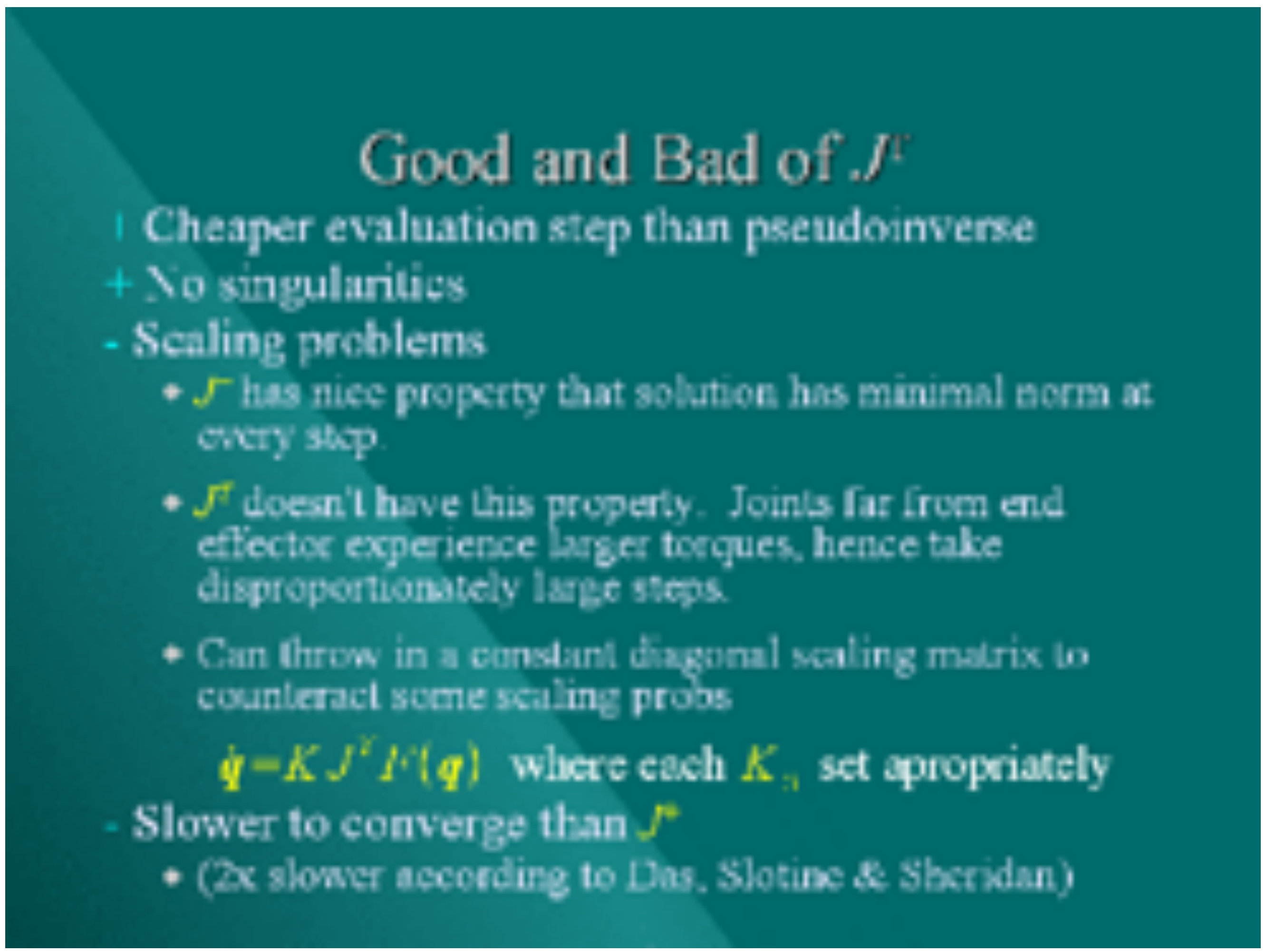

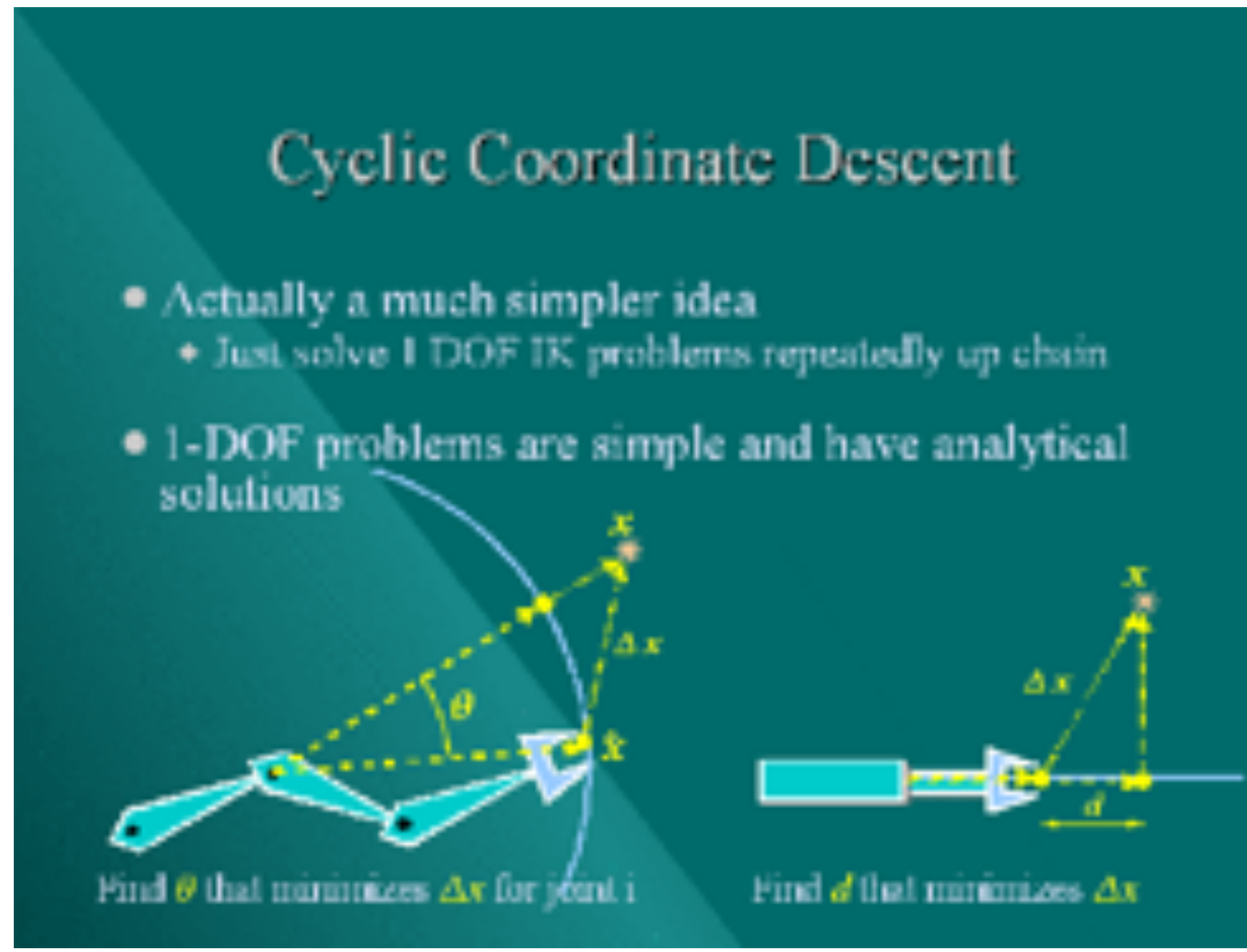

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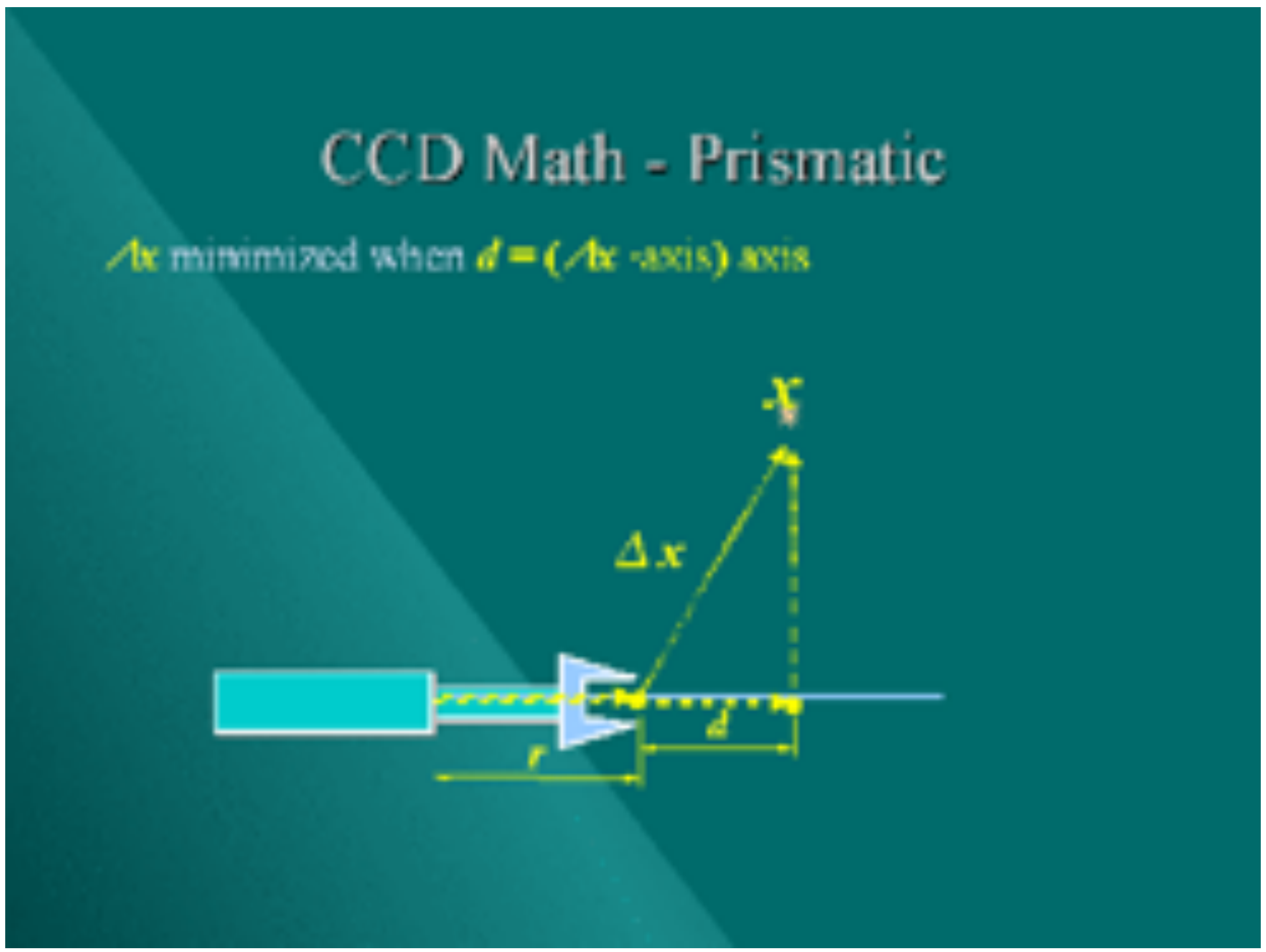

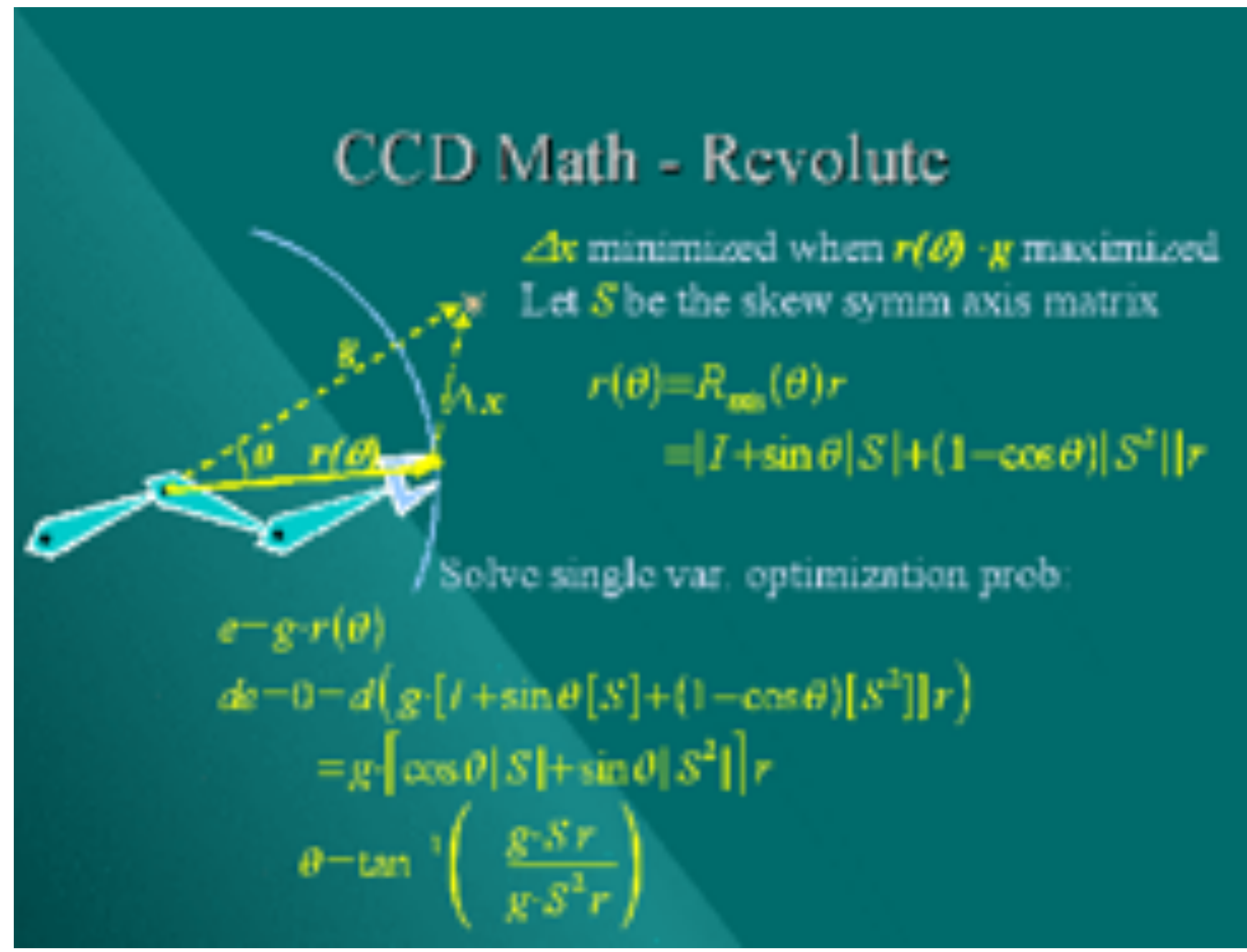

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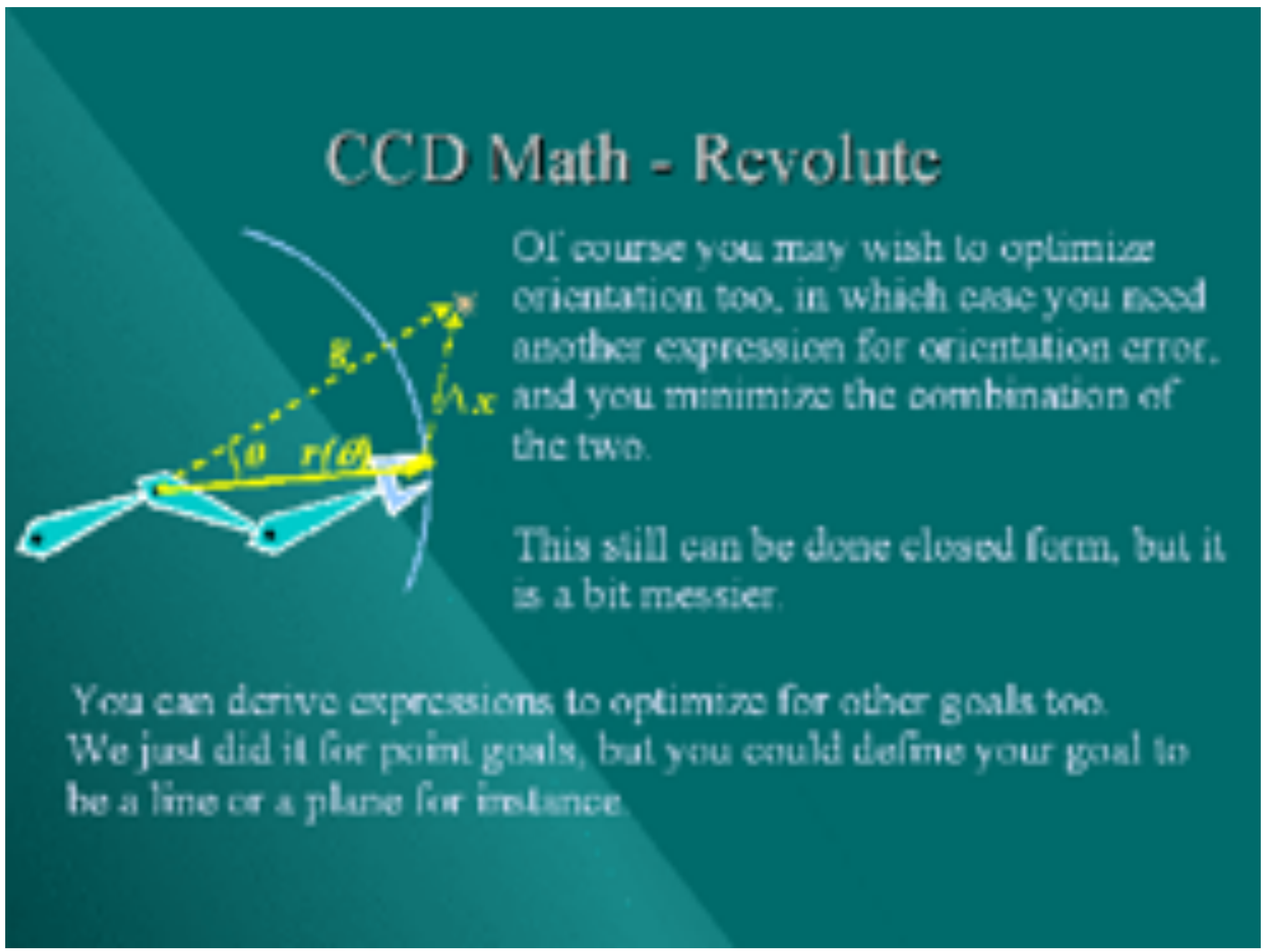

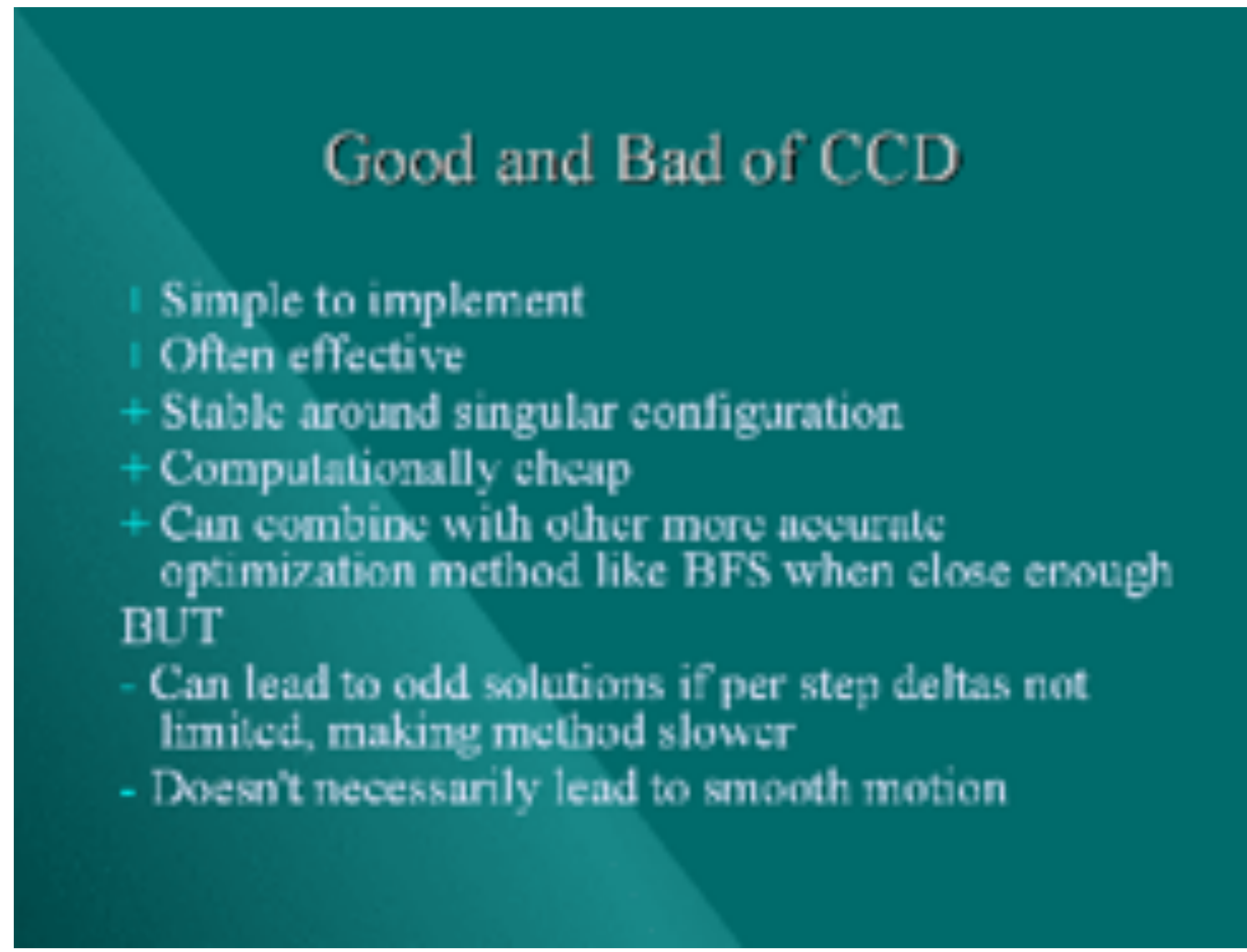

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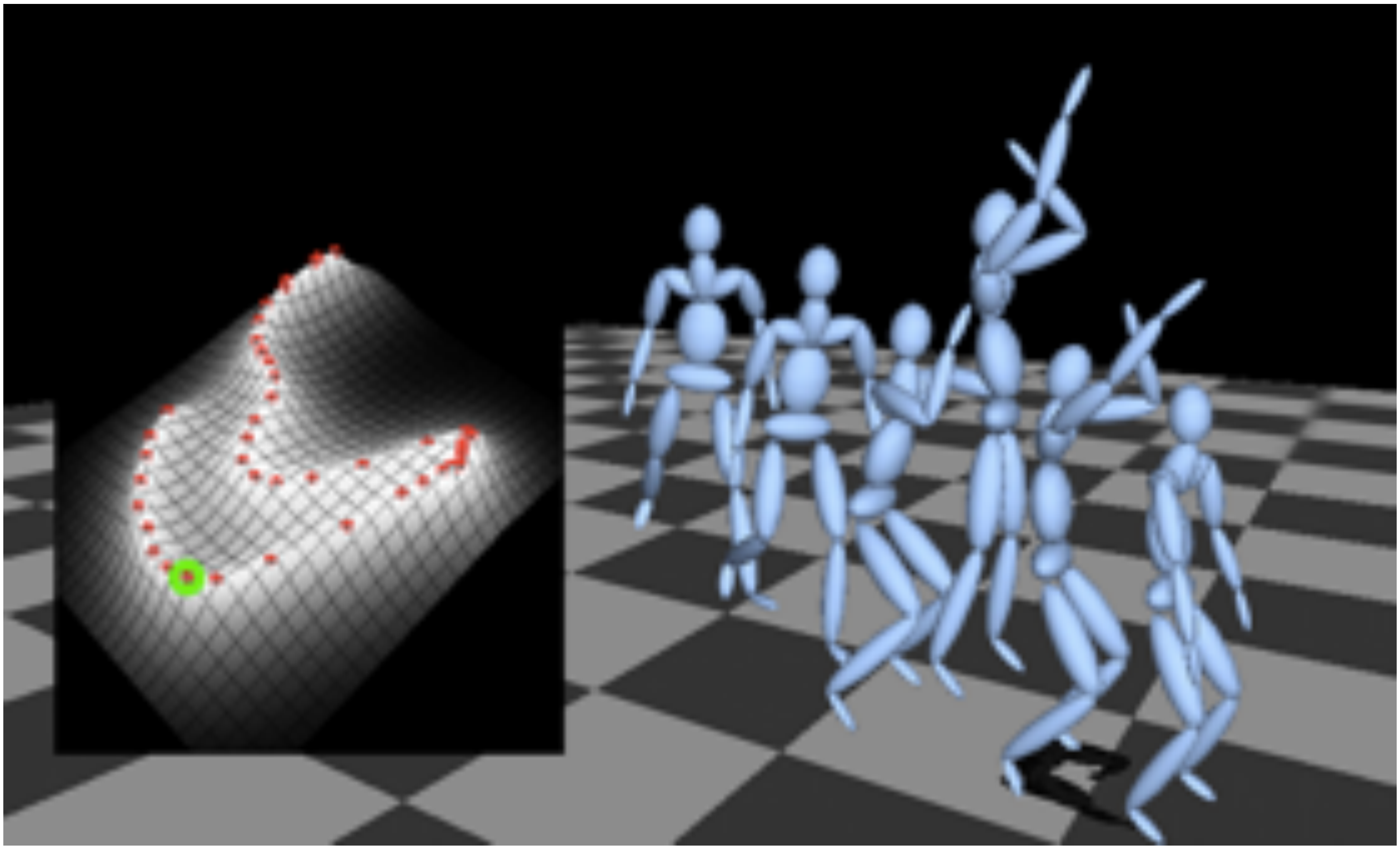
Paper 4 - Style-based Inverse Kinematics



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