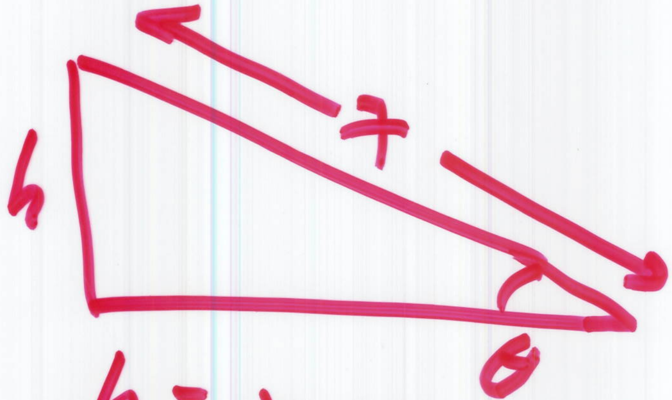
What is time t?

$$x = \frac{1}{3} g \sin\theta \, t^2 = \frac{h}{\sin\theta}$$



$$t = \sqrt{\frac{3h}{g}} \frac{1}{\sin\theta}$$

$$h = x \sin\theta$$

$$V = \frac{2}{3} g \sin\theta \, t = \frac{2}{3} g \sin\theta \sqrt{\frac{3h}{g}} \frac{1}{\sin\theta}$$

$$V = 2\sqrt{\frac{hg}{3}} = \sqrt{\frac{4hg}{3}}$$

1) Newton: $\vec{F} = m\vec{a} = m\frac{d^2\vec{r}}{dt^2}$

2) Energy Conservation: $\Delta E = 0$

3) Lagrange

Calculate the kinetic energy

$$K = \sum_i \frac{1}{2} m_i v_i^2 = T_{(t)}$$

time

Calculate the potential energy

$$U_{(t)} = \sum_i m_i g y_i + \text{a constant}$$

The quantity $T_{(t)} - U_{(t)} = L_{(t)}$

~~this this~~ the Lagrangian

The integral $\int_{-\infty}^{+\infty} L(t)\,dt = S$

action

The actual path, speed, acceleration, etc. is the one that extremizes S (usually, but not always, minimizes).

4) Hamilton

Define generalized coordinates

$$\{ q_1, q_2 \ldots q_n \}$$

lengths, angles, energies, Fourier coefficients...

$$L = T - U = L(q_1, q_2, \ldots q_n)$$

Form the "conjugate momentum"

$$p_i \equiv \frac{\partial L}{\partial \dot{q}_i}$$

Form Hamiltonian

$$H \equiv \left(\sum_i p_i \dot{q}_i\right) - L$$

$$\dot{q}_i = \frac{\partial H}{\partial p_i} \quad ; \quad \dot{p}_i = -\frac{\partial H}{\partial q_i}$$

two 1st order Differential Equations for each coordinate q.

$$\vec{D} = \vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$$

$$\vec{D} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

$$D_x = \hat{i} \begin{vmatrix} A_y & A_z \\ B_y & B_z \end{vmatrix}$$

$$D_x = \hat{i}(A_y B_z - A_z B_y)$$

$$D_1 = A_2 B_3 - A_3 B_2$$

Kronecker Delta Symbol

$$\delta_{ij} = \begin{cases} +1 & \text{if } i=j \\ 0 & \text{if } i \neq j \end{cases}$$

$$\delta_{11} = 1, \quad \delta_{22} = 1, \quad \delta_{12} = 0$$

$$\vec{r} = x\hat{e}_1 + y\hat{e}_2 + z\hat{e}_3$$

$$= x\hat{e}_x + y\hat{e}_y + z\hat{e}_z$$

$$= x\hat{i} + y\hat{j} + z\hat{k}$$

$$= x\hat{x} + y\hat{y} + z\hat{z}$$

$$v_1 = v_x = \frac{dx}{dt} \; ; \; v_2 = v_y = \frac{dy}{dt}$$

$\frac{df}{dt}$ Leibnitz notation

$\dot{f}$ Newton notation

$$a_1 = a_x = \frac{d^2x}{dt^2} = \ddot{x}$$

$$a_3 = a_z = \frac{d^2z}{dt^2} = \ddot{z}$$