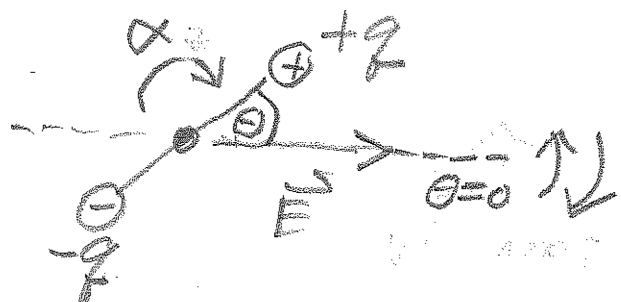
2-3-14

Sec 21.7

MECHANICAL EQUATIONS

— SMALL OSCILLATIONS ABOUT $\theta = 0$.
(CH 14)

$\tau_z = I\alpha$ (CH10)



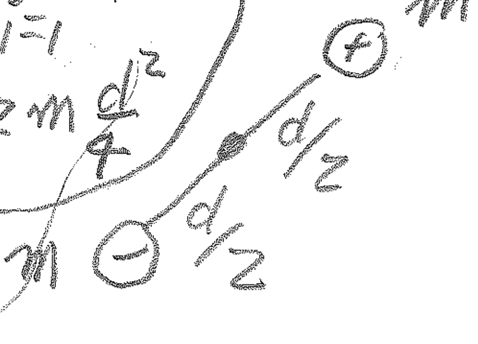
$$-pE\sin\theta = I\frac{d^2\theta}{dt^2}$$

$$-pE\theta = I\frac{d^2\theta}{dt^2} \quad \text{(see CH14)}$$

NOTE: $\sin\theta \approx \theta$ when $\theta \ll 1$

and I = moment of ROTATIONAL INERTIA about AXIS at center of DIPOLE (CH 9).

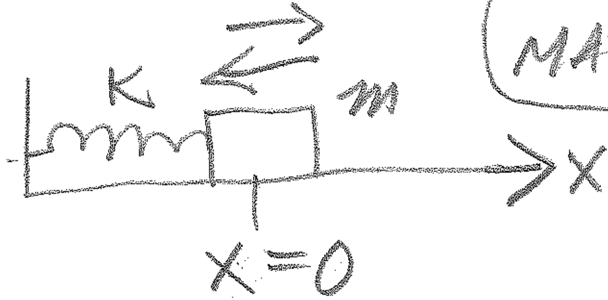
$$\boxed{I = \sum_{i=1}^{N} m_i r_i^2 = 2m\frac{d^2}{4}}$$



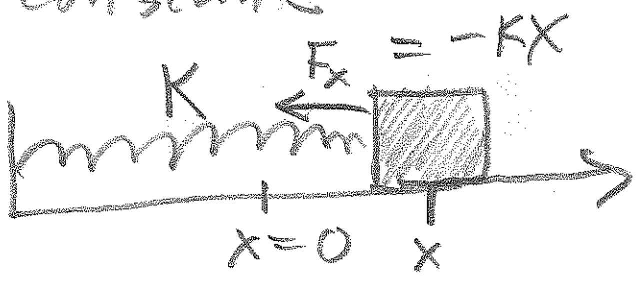
$$-pE\cdot\theta = I\frac{d^2\theta}{dt^2}$$

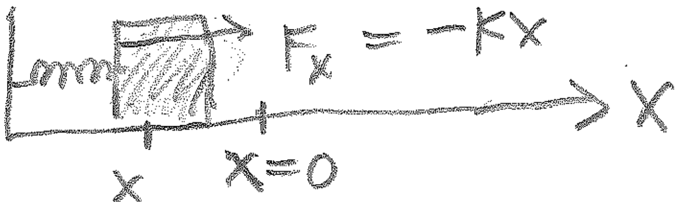
$$\Rightarrow \quad I\cdot\frac{d^2\theta}{dt^2} = -pE\cdot\theta$$

CH14 analog behavior:



MASS m connected TO spring with force constant K.





$$ma_x = -KX$$

$$m\frac{d^2x}{dt} = -Kx$$

MATH 4 SOLUTION (CH 14)

$$\Rightarrow \quad x = A\cos(\omega t + \phi)$$

$$\omega = \sqrt{\frac{K}{m}}$$

PHASE CONSTANT

THUS:

$$I \cdot \frac{d^2\theta}{dt^2} = -pE \cdot \theta$$

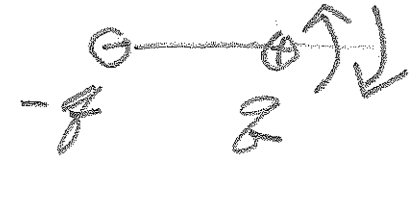
YIELDS,

$$\theta = A\cos(\omega t + \phi)$$

$$\omega = \sqrt{\frac{p \cdot E}{I}}$$

PHASE CONSTANT

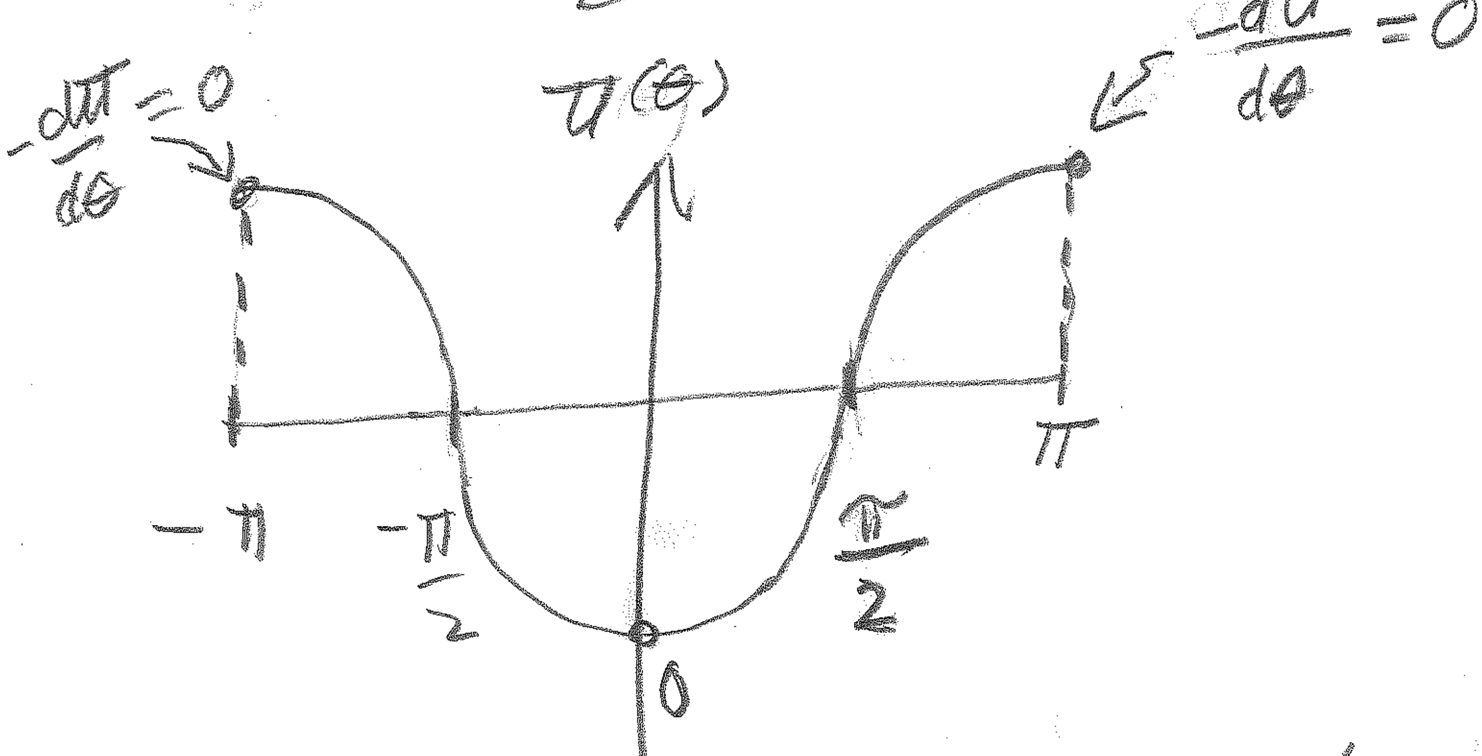
OSCILLATION FREQUENCY



HINTS TO QUIZ 1

comment on 59. — CH 21

see Lecture notes 1-31-14



STABLE EQUILIBRIUM at $\theta = 0$

NOTE: EQUILIBRIUM WHEN

$$-\frac{dU}{d\theta} = 0 = \tau_z$$

#59 — CH21

$$\tau_z = -\frac{dU}{d\theta}$$

$$U = -PE\cos\theta$$

$$\frac{dU}{d\theta} = PE\sin\theta$$

$$-\frac{dU}{d\theta} = -PE\sin\theta = \tau_z$$

$$\Rightarrow \boxed{\tau_z = -\frac{dU}{d\theta}}$$

NOTE: CH. 7, sec 7.4

<u>Review</u>:

$$F_x(x) = -\frac{dU}{dx}$$

$U(x) = U$ = POTENTIAL ENERGY

$U(x) = \frac{1}{2}kx^2$

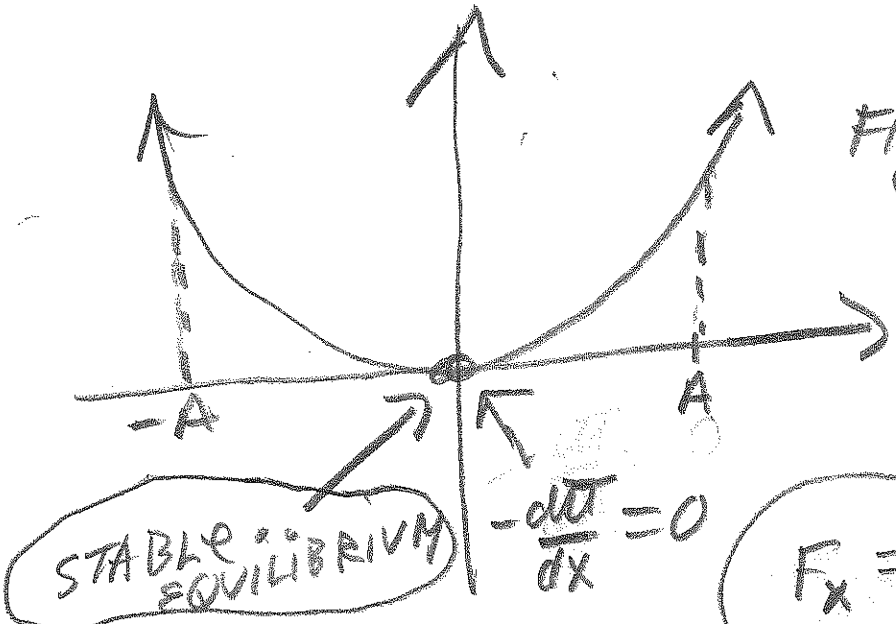
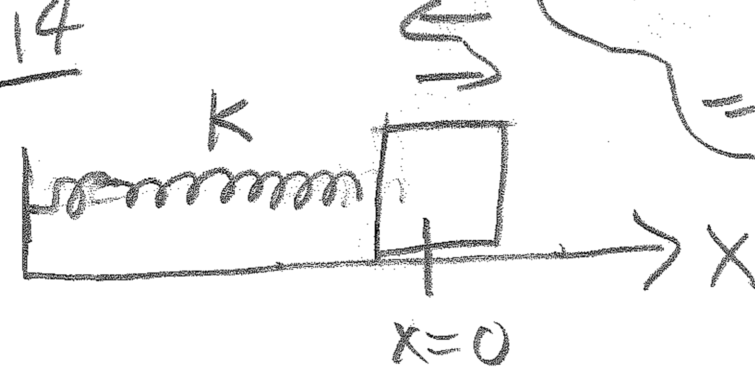
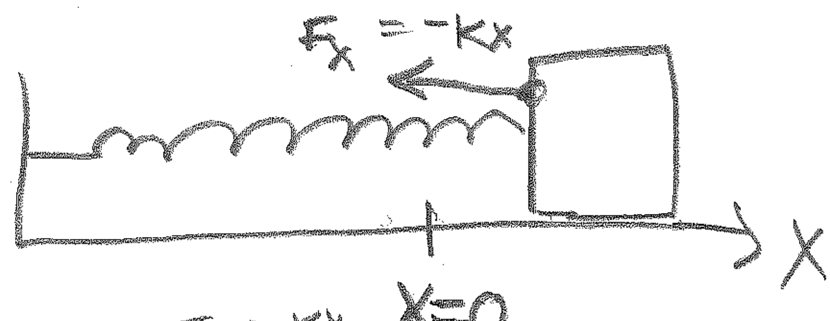


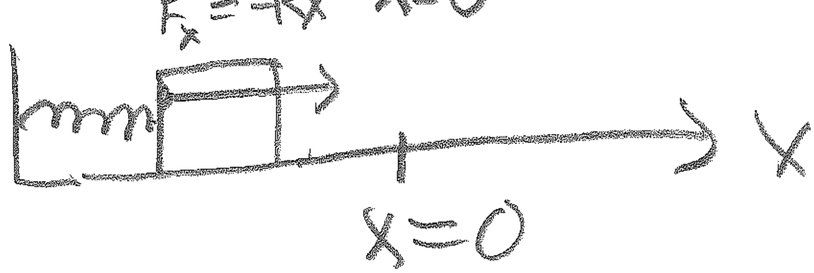
Fig 7.23

CH14

$$F_x = -\frac{dU}{dx} = -\frac{d\,\frac{1}{2}kx^2}{dx} = -kx$$







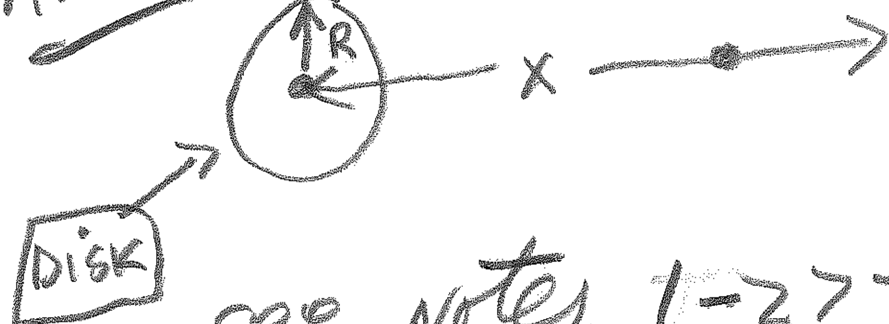
QUIZ 1 HINTS:

#55:

(c) DISCUSSION: POINT CHARGE BEHAVIOR.

ANALOGY:

$$E_x = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{1}{\sqrt{1+\frac{R^2}{x^2}}}\right]$$



see notes 1-27-14

limit (ii) $x \to \infty$ $(x \gg R)^*$

$$\frac{1}{\sqrt{1+\frac{R^2}{x^2}}} \approx 1 - \frac{R^2}{2x^2}$$ (TAYLOR'S EXPANSION)

$$E_x \approx \frac{\sigma}{2\varepsilon_0}\left[1 - \left(1 - \frac{R^2}{2x^2}\right)\right] = \frac{\sigma}{2\varepsilon_0} \cdot \frac{R^2}{2x^2}$$

---

* NOTE: $R \ll x < \infty$ ACTUALLY.

#55 (c.) Discussion:

$$E_x = \frac{\sigma}{2\varepsilon_0}\cdot\frac{R^2}{2x^2}$$

$$= \frac{\sigma\cdot\pi R^2}{4\pi\varepsilon_0 x^2}$$

$$= \frac{Q}{4\pi\varepsilon_0 x^2} = \frac{kQ}{x^2}$$

where $Q = \sigma\cdot\pi R^2$.

Behaves as point charge!