Information for the Quiz on Ch. 10 and Exam 3

Fundamental Concepts

Things you must know:

(1) Definition of and approximation for average velocity (and the position update formula)

(2) Definition of momentum $\qquad \gamma = \dfrac{1}{\sqrt{1-\left(|\vec{v}|/c\right)^2}}$

(3) The Momentum Principle (also, the momentum update formula and derivative form)

(4) Definitions of total energy, rest energy, and kinetic energy of a particle

(5) The Energy Principle – *be able to apply to "point particle" systems and real systems*

(6) The Angular Momentum Principle

Definitions and Specific Results

Projectile Motion: $\quad x_f = x_i + v_{xi}\Delta t \qquad y_f = y_i + v_{yi}\Delta t - \frac{1}{2}g\left(\Delta t\right)^2$

$\qquad\qquad\quad v_{xf} = v_{xi} \qquad v_{yf} = v_{yi} - g\Delta t$

$\vec{\mathrm{F}}_{\text{grav on 2 by 1}} = -G\dfrac{m_1 m_2}{|\vec{\mathrm{r}}|^2}\hat{\mathrm{r}} \qquad U_{\text{grav}} = -G\dfrac{m_1 m_2}{|\vec{\mathrm{r}}|}$

$\left|\vec{\mathrm{F}}_{\text{grav}}\right| \approx mg$ near Earth's surface $\qquad U_{\text{grav}} \approx mgy$ near Earth's surface

$\vec{\mathrm{F}}_{\text{elec on 2 by 1}} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{|\vec{\mathrm{r}}|^2}\hat{\mathrm{r}} \qquad U_{\text{elec}} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{|\vec{\mathrm{r}}|}$

$\left|\vec{\mathrm{F}}_{\text{spring}}\right| = k_s|s| \qquad U_{spring} = \frac{1}{2}k_s s^2$

$U_i \approx \frac{1}{2}k_s s^2 - E_m \qquad \Delta E_{thermal} = mC\Delta T$

$\vec{\mathrm{F}}_{air} \approx -\frac{1}{2}C\rho A v^2\hat{\mathrm{v}} \qquad \left|\vec{\mathrm{F}}_{buoyancy}\right| =$ weight of displaced fluid

$K \approx \frac{1}{2}mv^2 = \dfrac{p^2}{2m}$ for $v << c \qquad E^2 - \left(pc\right)^2 = \left(mc^2\right)^2 \qquad W = \vec{\mathrm{F}}\cdot\Delta\vec{\mathrm{r}}$ (small displacement)

$Y = \dfrac{F_T/A}{\Delta L/L}$ (macro) $\qquad Y = \dfrac{k_{s,i}}{d}$ (micro) $\qquad v = d\sqrt{\dfrac{k_{s,i}}{m_a}}$

$\vec{\mathrm{F}}_{\parallel} = \dfrac{d|\vec{\mathrm{p}}|}{dt}\hat{\mathrm{p}} \qquad \vec{\mathrm{F}}_{\perp} = |\vec{\mathrm{p}}|\dfrac{d\hat{\mathrm{p}}}{dt} = |\vec{\mathrm{p}}|\dfrac{|\vec{\mathrm{v}}|}{R}\hat{\mathrm{n}}$

$x(t) = A\cos(\omega t) \qquad \omega = \sqrt{\dfrac{k_s}{m}} \qquad T = \dfrac{2\pi}{\omega}$

$\vec{\mathrm{L}}_A = \vec{\mathrm{r}}_A \times \vec{\mathrm{p}} \qquad \vec{\tau}_A = \vec{\mathrm{r}}_A \times \vec{\mathrm{F}} \qquad \left|\vec{\mathrm{A}}\times\vec{\mathrm{B}}\right| = AB\sin\theta$

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Multiparticle Systems: $\vec{r}_{cm} = \dfrac{m_1\vec{r}_1 + m_1\vec{r}_1 + \ldots}{m_1 + m_2 + \ldots}$ $\qquad \vec{P}_{tot} \approx M\vec{v}_{cm} \quad (v \ll c)$

$K_{tot} = K_{trans} + K_{rel}$ $\qquad K_{trans} \approx \frac{1}{2}Mv_{cm}^2 \,(v \ll c)$ $\qquad K_{rel} = K_{rot} + K_{vib}$ $\qquad K_{rot} = \frac{1}{2}I\omega^2$

$\vec{L}_{tot,A} = \vec{L}_{trans,A} + \vec{L}_{rot}$ $\qquad \vec{L}_{trans,A} = \vec{r}_{cm,A} \times \vec{P}_{tot}$ $\qquad \vec{L}_{rot} = I\vec{\omega}$ $\qquad I = m_1 r_{1\perp}^2 + m_2 r_{2\perp}^2 + \ldots$

Physical Constants

$c = 3\times10^8$ m/s $\qquad g = 9.8$ m/s^2 $\qquad G = 6.7\times10^{-11}\,\mathrm{N\cdot m^2/kg^2}$

$m_{\text{proton}} = 1.7\times10^{-27}$ kg $\qquad m_{\text{electron}} = 9\times10^{-31}$ kg $\qquad N_A = 6.02\times10^{23}$ atoms/mole

$e = 1.6\times10^{-19}\,\mathrm{C}$ $\qquad 1/4\pi\varepsilon_0 = 9\times10^9\,\mathrm{N\cdot m^2/C^2}$ $\qquad 1\ \mathrm{eV} = 1.6\times10^{-19}\,\mathrm{J}$