

## PHY2048 Course Overview

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**Units and Measurement** – Chapter 1. Every answer must have the appropriate units to be correct.

**Vectors** – Chapters 3, 4, 5, 6, 8, 10, 11, 12.

You must know all of the basics of trigonometry and be able to work with vector components.

Find scalar (dot) product, vector (cross) product, arbitrary unit vector =  $(x\hat{i} + y\hat{j} + z\hat{k}) / r$ .

**Conservation of Energy** – Chapters 6, 7, 9, (10-1), R, 11, 14, 17, 18, 19.

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2, \quad K_f - K_i = W_{\text{net}}; \quad E = K + U, \quad E_f - E_i = W_{\text{ext}}.$$

$$\text{Relativistic total energy } E = K + mc^2 = \gamma mc^2; \quad E^2 = (pc)^2 + (mc^2)^2, \quad v/c = pc/E.$$

**Work, Potential Energy, and Power** – Chapters 6, 7, also 11-3.

$$W = \int \vec{F} \cdot d\vec{s} \rightarrow \vec{F} \cdot \vec{s}, \quad U_f - U_i = -\int_i^f F_x dx, \quad P = \frac{dW}{dt} \rightarrow \vec{F} \cdot \vec{v};$$

also special cases:  $U(x) = \frac{1}{2}kx^2$  for a spring,  $U(y) = mgy$  for constant gravity field.

**Gravity** – Chapter 11, 4, 6.

$$\vec{F} = \frac{GMm}{r^2}(-\hat{r}) \rightarrow mg(-\hat{j}); \quad U = -\frac{GMm}{r} \rightarrow \Delta U = mg(y_f - y_i).$$

**Conservation of Momentum** – Chapters 8, 13, 17-5.

$$\vec{p} = m\vec{v} \quad (\text{relativistic } p = \gamma mv); \quad \sum \vec{p}_i = \sum \vec{p}_f \quad \text{if } \vec{F}_{\text{net}} = 0; \quad \left( \vec{F} = \frac{d\vec{p}}{dt} \right).$$

**Linear Motion** – Chapters 2, 3, 4, 5.

$$\vec{F}_{\text{net}} = m\vec{a}, \quad \text{where } \vec{a} = \frac{d\vec{v}}{dt} \quad \text{and } \vec{v} = \frac{d\vec{r}}{dt}, \quad \text{plus the 4 equations for constant acceleration:}$$

$$\vec{v}_f(t) = \vec{v}_0 + \vec{a}t, \quad \vec{r}_f(t) = \vec{r}_0 + \vec{v}_0t + \frac{1}{2}\vec{a}t^2, \quad v_f^2 - v_0^2 = 2\vec{a} \cdot \vec{s}, \quad \vec{r}_f(t) = \vec{r}_0 + \vec{v}_{\text{avg}}t.$$

**Oscillations (simple harmonic motion)** – Chapters 14.

$$A \cos(\omega t + \phi), \quad \omega = 2\pi f = \frac{2\pi}{T}; \quad \omega = \sqrt{\frac{k}{m}} \quad \text{for spring; } \omega = \sqrt{\frac{g}{L}} \quad \text{for pendulum.}$$

**Torque and Moment of Inertia** – Chapters 9, 10.

$$\vec{\tau} = \vec{r} \times \vec{F} \rightarrow [\text{lever arm}]|\vec{F}| \text{ or } |\vec{r}|F_{\perp}, \quad I = \sum m_i r_i^2 \text{ and superposition principle.}$$

**Conservation of Angular Momentum** – Chapter 10.

$$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}; \quad \sum \vec{L}_i = \sum \vec{L}_f \text{ if } \vec{\tau}_{net} = 0; \quad \left( \vec{\tau} = \frac{d\vec{L}}{dt} \right).$$

**Circular Motion** – Chapters 3, 5, 9, 10.

radial:  $a_{\text{radial}} = v^2 / r$  due to a centripetal force =  $m\vec{a}_{\text{radial}}$ .

tangential:  $t_{\text{net}} = I\vec{a}$ , where  $\vec{a} = \frac{d\vec{\omega}}{dt}$  and  $\vec{\omega} = \frac{d\vec{q}}{dt}$ , plus 4 equations for constant  $\vec{a}$ :

$$w(t) = w_0 + at, \quad q(t) = q_0 + w_0 t + \frac{1}{2}at^2, \quad w_f^2 - w_0^2 = 2aq, \quad q(t) = q_0 + w_{\text{avg}}t$$

**plus** angular to linear (tangential) relations:  $a_{\text{tang}} = ar$ ,  $v_{\text{tang}} = wr$ ,  $s = rq$ .

**Statics** – Chapters 4, 5, 9, 12.

$$\sum F_x = 0 \text{ and } \sum F_y = 0, \text{ plus } \sum t = 0 \text{ about any axis.}$$

**Waves** – Chapters 15, 16.

$$A \sin(kx - wt), \quad k = \frac{2\pi}{\lambda}, \quad w = \frac{2\pi}{T} = 2\pi f; \quad v = fl = \frac{w}{k}; \text{ Linear superposition.}$$

Standing waves, beat frequency; Doppler shifted  $f' = \frac{v+u_r}{v-u_s} f$ .

**Fluid Mechanics** – Chapter 13.

$$F = PA, \quad \Delta P = -\rho g \Delta y; \quad A_1 v_1 = A_2 v_2, \quad P + \frac{1}{2}\rho v^2 + \rho gy = \text{const.}$$

**Thermodynamics** – Chapters 17, 18, 19, 20.

$$Q_{\text{cold}} = -Q_{\text{hot}}, \quad Q = mc\Delta T \text{ or } mL \text{ or } nC_{\text{v}}\Delta T; \quad W_{\text{by}} = \int PdV \rightarrow P\Delta V \text{ (const P).}$$

$$\Delta E_{\text{int}} = Q - W; \quad \text{ideal gas: } PV = nRT = Nk_B T, \quad K_{\text{avg}} = \frac{3}{2}k_B T, \quad \Delta E_{\text{int}} = nC_V \Delta T.$$

Heat engines:  $W = Q_{\text{hot}} - Q_{\text{cold}}$ ,  $e = \frac{W}{Q_{\text{hot}}}$ ,  $e_C = \frac{T_{\text{hot}} - T_{\text{cold}}}{T_{\text{hot}}}$ ;  $\text{COP} = \frac{Q}{W}$ .

Thermal expansion:  $\Delta L / L = \alpha \Delta T$ ; thermal conduction:  $\Delta Q / \Delta t = kA \Delta T / \Delta x$ .