1 Formulas for Midterm Exam 1 (Physics 125)

One dimensional motion in x

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \quad (1)$$
$$v = v_0 + at \quad (2)$$
$$v^2 = v_0^2 + 2a(x - x_0) \quad (3)$$

Projectile Motion

x	y
$x = x_0 + v_{0x}t$	$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$
$v_x = v_{0x}$	$v_y = v_{0y} - gt$
$v_x^2 = v_{0x}^2$	$v_y^2 = v_{0y}^2 - 2g(y - y_0)$

Relative velocity

$$\vec{v}_{P/B} = \vec{v}_{P/A} + \vec{v}_{A/B} \quad (4)$$

Forces

$$\Sigma\vec{F} = m\vec{a} \quad (5)$$

$$\vec{w} = m\vec{g}, \quad (6)$$
$$f_s \leq \mu_s n, \quad (7)$$
$$f_k = \mu_k n. \quad (8)$$

Circular Motion

$$a_{\text{rad}} = \frac{v^2}{R} \quad (9)$$

2 Formulas for Midterm Exam 2 (Physics 125)

All formulas from Midterm 1 +

Work and Energy

$$\begin{aligned} W &= \vec{F}\cdot\vec{s} = Fs\cos\theta = F_{\parallel}s, && (10)\\ K &= \frac{1}{2}mv^2, && (11)\\ U_{\text{gravity}} &= mgy, && (12)\\ U_{\text{spring}} &= \frac{1}{2}kx^2. && (13) \end{aligned}$$

Work-Energy Theorem (general)

$$K_1 + U_1 + W_{other} = K_2 + U_2. \quad (14)$$

In the absence of nonconservative forces the mechanical energy is conserved!

$$K_1 + U_1 = K_2 + U_2. \quad (15)$$

Momentum and Impulse

$$\begin{aligned} \vec{p} &= m\vec{v}, && (16)\\ \vec{P}_{\text{tot}} &= \sum_i m_i\vec{v}_i, && (17)\\ & && (18) \end{aligned}$$

Second Newton's Law

$$\vec{F}_{\text{ext tot}} = \frac{d\vec{P_{\text{tot}}}}{dt}. \quad (19)$$

In the absence of external forces the total momentum of the system is conserved!

$$\vec{P}_{\text{tot}} = const. \quad (20)$$

Collisions

Momentum is conserved in *any* collisions $\vec{P}_1 = \vec{P}_2$ or

$$m_A\vec{v}_{A1} + m_B\vec{v}_{B1} = m_A\vec{v}_{A2} + m_B\vec{v}_{B2}. \quad (21)$$

In *completely inelastic* collisions particle stick together after collision $\vec{v}_{A2} = \vec{v}_{B2} = \vec{v}_2$ and

$$m_A\vec{v}_{A1} + m_B\vec{v}_{B1} = (m_A + m_B)\vec{v}_2. \quad (22)$$

In *perfectly elastic* collisions kinetic energy is conserved $K_1 = K_2$ or

$$\frac{1}{2}m_A v_{A1}^2 + \frac{1}{2}m_B v_{B1}^2 = \frac{1}{2}m_A v_{A2}^2 + \frac{1}{2}m_B v_{B2}^2. \tag{23}$$

In *perfectly elastic* collisions for *one-dimensional motion* one can replace conservation of kinetic energy (23) (with the use of (21)) by simpler formula

$$v_{B1x} - v_{A1x} = -(v_{B2x} - v_{A2x}). \tag{24}$$

Rotation

Rotation – Translation Correspondence:

Translation	Rotation	
x or s	θ	$\theta = s/r$
$v = \frac{dx}{dt}$	$\omega = \frac{d\theta}{dt}$	$\omega = v/r$
$a = \frac{dv}{dt}$	$\alpha = \frac{d\omega}{dt}$	$\alpha = a/r$
m	I	$I = \Sigma mr^2$
$K = \frac{1}{2}mv^2$	$K = \frac{1}{2}I\omega^2$	$K = \frac{1}{2}\Sigma mv^2$

Units of angle

$$2\pi \text{ rad} = 360^o = 1 \text{ rev}. \tag{25}$$

Rotational motion with $\alpha = const$

$$\alpha = const, \tag{26}$$

$$\omega = \omega_0 + \alpha t, \tag{27}$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2. \tag{28}$$

Moment of inertia

$$I = \sum_i m_i r_i^2. \tag{29}$$

Parallel Axis Theorem

$$I_P = I_{cm} + Md^2. \tag{30}$$

3 Formulas for Final Exam (Physics 125)

All formulas from Midterms 1 and 2 +

Dynamics of rotational motion

Rotation – Translation Correspondence:

Translation	Rotation	
m	I	$I = \Sigma m r^2$
$K = \frac{1}{2} m v^2$	$K = \frac{1}{2} I \omega^2$	$K = \frac{1}{2} \Sigma m v^2$
F	τ	$\vec{\tau} = \vec{r} \times \vec{F}$, $\tau = r_\perp F = r F_\perp$
p	L	$\vec{L} = \vec{r} \times \vec{p}$, $L = I\omega$

$$\sum \tau = I\alpha \tag{31}$$

$$K_{\text{rotation}} = \frac{1}{2} I \omega^2 \tag{32}$$

$$K = \frac{1}{2} M v_{cm}^2 + \frac{1}{2} I_{cm} \omega^2 \tag{33}$$

$$W_{\text{rotation}} = \tau \Delta\theta \tag{34}$$

$$\sum \vec{\tau} = \frac{d\vec{L}}{dt}, \tag{35}$$

$$\sum \tau_z = \frac{dL_z}{dt} = I\alpha_z. \tag{36}$$

Equilibrium

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum F_z = 0 \qquad \text{(1st condition)} \tag{37}$$

$$\sum \vec{\tau} = 0, \quad \text{about any point} \qquad \text{(2nd condition)} \tag{38}$$

$$\vec{r}_{cm} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i} \tag{39}$$

Elasticity

$$\text{Elastic modulus} = \frac{\text{Stress}}{\text{Strain}}. \tag{40}$$

$$Y = \frac{\text{Tensile stress}}{\text{Tensile strain}} = \frac{F_\perp / A}{\Delta l / l_0} \quad \text{(Young's modulus)}. \tag{41}$$

Newtonian Gravity

$$F_g = \frac{Gm_1m_2}{r^2}, \tag{42}$$

$$G = 6.67 \times 10^{-11} \frac{N \times m^2}{kg^2}. \tag{43}$$

$$g = \frac{Gm_{\mathrm{E}}}{R_{\mathrm{E}}^2} = 9.8 \frac{m}{s^2}. \tag{44}$$

$$U = -\frac{Gm_1m_2}{r}. \tag{45}$$