Physics 317K
Formula Sheet

Math:

sin = opposite/hypotenuse, cos = adjacent/hypotenuse
tan = opposite/adjacent, $a_x = a \cos\theta$, $a_y = a \sin\theta$

One dimensional motion

displacement: $\Delta x = x_2 - x_1$
average velocity: $v_{avg} = \frac{\Delta x}{\Delta t}$
instantaneous velocity: $v = \frac{dx}{dt}$
average acceleration: $a_{avg} = \frac{\Delta v}{\Delta t}$
instantaneous acceleration: $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$
kinematic equation 1: $v = v_0 + at$
kinematic equation 2: $x - x_0 = v_0 t + \frac{1}{2}at^2$
kinematic equation 3: $v^2 = v_0^2 + 2a(x - x_0)$
kinematic equation 4: $x - x_0 = \frac{1}{2}(v_0 + v)\,t$
kinematic equation 5: $x - x_0 = vt - \frac{1}{2}at^2$

Projectile motion

kinematic equation 1: $x - x_0 = (v_0 \cos\theta)t$
kinematic equation 2: $y - y_0 = (v_0 \sin\theta)t - \frac{1}{2}gt^2$
kinematic equation 3: $v_y = v_0 \sin\theta - gt$
kinematic equation 4: $v_y^2 = (v_0 \sin\theta)^2 - 2g(y - y_0)$

Newtons Laws

Force $F = ma$, Weight $W = mg$
equilibrium conditions: $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma F_z = 0$
non-equilibrium conditions: $\Sigma F_x = ma_x$, $\Sigma F_y = ma_y$, $\Sigma F_z = ma_z$
static friction force $f_s \leq \mu_s F_n$
kinetic friction force $f_k = \mu_k F_n$

Work and Energy

work: $W = F \cos\theta\, \Delta x$, work $\theta = 0$: $W = F\, \Delta x$
potential energy: $U = mgy = mgh$
elastic potential energy stored in a spring: $U_s = \frac{1}{2}kx^2$
kinetic energy: $K = \frac{1}{2}mv^2$
work energy theorem: $W_{net} = K_f - K_i$
energy conservation: $K_i + U_i = K_f + U_f$
non-conservative work: $W_{nc} = (K_f + U_f) - (K_i + U_i)$
power: $P = \frac{E}{t} = Fv$

Momentum conservation and collisions

momentum: p = mv, impulse = F Δt

impulse-momentum theorem: F Δt = Δp = mv_f-mv_i

conservation of momentum in collisions: $\Sigma(mv)_{initial} = \Sigma(mv)_{final}$

Rotational motion

rotational equation 1: $\omega = \omega_0 + \alpha t$

rotational equation 2: $\theta - \theta_0 = \omega_0 t + \frac{1}{2}\alpha t^2$

rotational equation 3: $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

rotational equation 4: $\theta - \theta_0 = \frac{1}{2}(\omega_0 + \omega)\, t$

rotational equation 5: $\theta - \theta_0 = \omega t - \frac{1}{2}\alpha t^2$

tangential velocity: $v_t = \omega\, r$

tangential acceleration: $a_t = \alpha\, r$

centripetal (radial) acceleration: $a_r = \frac{v^2}{r} = \omega^2\, r$

total acceleration: $a = \sqrt{(a_r^2 + a_t^2)}$

centripetal force: $F_r = m\, a_r = m\, \frac{v^2}{r}$

Rotational equilibrium and dynamics

rotational kinetic energy: $K_r = \frac{1}{2} I\, \omega^2$

moment of inertia: $I = \Sigma\, m_i r_i^2$

I of uniform disc = $\frac{1}{2} M\, R^2$

torque: τ = Fd (d=r sin θ), torque: $\tau = I\, \alpha$

equilibrium conditions $\rightarrow$ $\Sigma\, F_x = 0$, $\Sigma\, F_y = 0$, $\Sigma\, \tau = 0$

angular momentum: $L = I\, \omega$

angular momentum conservation: $I_i \omega_i = I_f \omega_f$

Conversion factors and Constants:

1 ft = 12 in

1 km = 1000 m

1 m = 100 cm = 1000 mm = 3.28 ft

1 ton = 1000 kg

gravitational acceleration a = -g = -9.8 [m/s^2]