FORMULA SHEET

DATA

gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

FORMULAE

uniformly accelerated motion	$v = v_0 + at$ $x = x_0 + v_0 t + \frac{1}{2}at^2$ $x - x_0 = \frac{1}{2}(v_0 + v)t$ $v^2 = v_0{}^2 + 2a(x - x_0)$
Newton's 2nd Law	$F = ma$
maximum static frictional force	$f_{s,\,\max} = \mu_s N$
kinetic frictional force	$f_k = \mu_k N$
Momentum of a particle:	$\mathbf{p} = m\mathbf{v}$
Impulse-Momentum Theory	$\Delta p_{\mathrm{x}} = p_{\mathrm{fx}} - p_{\mathrm{ix}} = J_{\mathrm{x}}$
impulse of a constant force	$J = F\Delta t$
impulse of a variable force	$J_x = \int_{t_i}^{t_f} F_x(t)\,\mathrm{d}t$
Conservation of Momentum for an Isolated System:	$\mathbf{P}_{\mathrm{f}} = \mathbf{P}_{\mathrm{i}}$
Newton's 2nd Law for Impulse	$\sum \mathbf{F} = \frac{d\mathbf{p}}{dt}$
Kinetic Energy	$K = \frac{1}{2}mv^2$
Work Energy Theorem	$W_{\mathrm{total}} = \Delta K$
Gravitational Potential Energy:	$U_g = mg\Delta y$ (y positive upward)
Elastic Potential Energy:	$U_s = \frac{1}{2}kx^2$ ($x_{\mathrm{e}} = 0$)
Work done by gravitational force:	$W_g = -\Delta U_g$

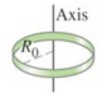
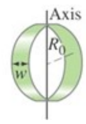
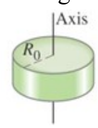
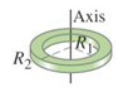
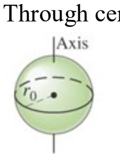
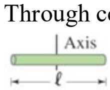
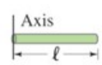
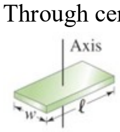
$T = 2\pi\sqrt{\frac{l}{g}}$

Circular force

$F = \frac{mv^2}{r}$

Work done by spring force:	$W_s = -\Delta U_s$
Force and Potential Energy:	$F = -\frac{dU}{dx}$; $U = -\int_{x_0}^{x} F(x)\,dx$
Conservation of Energy:	$U_1 + K_1 + W_{nc} = U_2 + K_2$
average power	$P_{\text{average}} = \frac{\Delta W}{\Delta t}$
instantaneous power	$P_{\text{instantatneous}} = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = \frac{\mathrm{d}W}{\mathrm{d}t} = \vec{F} \bullet \vec{v}$
Rotational Kinematics	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ $\theta = \theta_0 + \bar{\omega} t$ $\omega = \omega_0 + \alpha t$ $\bar{\omega} = \frac{1}{2}(\omega + \omega_0)$ $\theta = \theta_0 + \bar{\omega} t$ $\omega^2 = \omega_0^{\ 2} + 2\alpha[\theta - \theta_0]$ $\theta - \theta_0 = \frac{1}{2}[\omega_0 + \omega]t$
Linear Speed	$v = r\omega$
Tangential acceleration:	$a_{\tan} = r\alpha$
Radial acceleration:	$a_{rad} = r\omega^2$
Kinetic energy of rigid body	$KE = \frac{1}{2} M v_{\text{c.m}}^{\ 2} + \frac{1}{2} I_{\text{c.m}} \omega^2$
Angular momentum of rigid body	$L = I\omega$
Moment of Inertia:	$I = \sum_i m_i r_i^2$
Parallel Axis Theorem	$I_{\text{p}} = I_{\text{cm}} + Md^2$

Moment of Inertia of objects of different shapes

Object	**Location of axis**	**Moment of Inertia**
Thin Hoop (mass M, radius R_0)	Through centre 	$MR_0^{\ 2}$
Thin Hoop (mass M, radius R_0, width w)	Through central diameter 	$\frac{1}{2}MR_0^{\ 2}+\frac{1}{2}Mw^2$
Solid Cylinder (radius R_0)	Through centre 	$\frac{1}{2}MR_0^{\ 2}$
Hollow Cylinder (inner radius R_1, outer radius R_2)	Through centre 	$\frac{1}{2}M\left(R_1^{\ 2}+R_2^{\ 2}\right)$
Uniform Sphere (radius R_0)	Through centre 	$\frac{2}{5}MR_0^{\ 2}$
Long uniform rod (length l)	Through centre 	$\frac{1}{12}Ml^2$
Long uniform rod (length l)	Through end 	$\frac{1}{3}Ml^2$
Rectangular Thin Plate (length l, width w)	Through centre 	$\frac{1}{12}M\left(l^2+w^2\right)$

Defining equation for simple harmonic motion $\quad a=-\omega^2 x$

Speed of a wave $\quad v=f\lambda$

Velocity of transverse wave on stretched string $\quad v=\sqrt{\frac{F_T}{\mu}}$ where $\mu=\frac{m}{l}$, F_T : tension

General representation of a travelling wave $\quad D(x,t)=A\sin\,(kx\pm\omega t+\phi)$

Wavelength of n^{th} harmonic frequency for a resonant length l $\quad \lambda_n=\frac{2l}{n},\quad n=1,2,3,\ldots$

Condition for constructive interference, for a double slit with separation distance *d*	$d\sin\theta = m\lambda\,, \qquad m = 0,1,2,3\,\ldots$
Condition for destructive interference, for a double slit with separation distance *d*	$d\sin\theta = \left(m + \frac{1}{2}\right)\lambda, \quad m = 0,1,2,3\,\ldots$
Small angle approximation	$\sin\theta \approx \theta; \quad \tan\theta \approx \theta$
Condition for minima in diffraction pattern of single slit with width *D*	$D\sin\theta \;=\; m\lambda, \quad m = \pm 1, \pm 2\,, \pm 3, \ldots.$