Reference Sheet

Centripetal acceleration of an object in uniform circular motion:

$$a_c = \frac{v_T^2}{r} \text{ or } \omega^2 r$$

Tangential velocity $v_T = \omega r$

Newton's law of universal gravitation: $F_g = \frac{Gm_1m_2}{r^2}$, where r is the distance between the centers of the objects

Newton's second law: $\vec{F} = m\vec{a}$
Newton's third law: $\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$

Kinematics of constant acceleration:

$$\begin{aligned} x(t) &= \frac{1}{2}at^2 + v_0 t + x_0 \\ v(t) &= at + v_0 \\ v_f^2 - v_0^2 &= 2a\Delta x \end{aligned}$$

Analogue for circular motion:

$$\begin{aligned} \theta(t) &= \frac{1}{2}\alpha t^2 + \omega_0 t + \theta_0 \\ \omega(t) &= \alpha t + \omega_0 \\ \omega_f^2 - \omega_0^2 &= 2\alpha\Delta\theta \end{aligned}$$

1 revolution = 360 degrees = 2π radians

Maximum force of static friction: $\mu_s F_N$
Force of kinetic friction: $\mu_s F_N$

Gravitational constant: $G = 6.67 \times 10^{-11} \text{N} \cdot \text{m}^2/\text{kg}^2$
(other numeric constants will be given in problems if required)

Momentum: $\vec{p} = m\vec{v}$
Conservation of momentum: $\sum \vec{p}_i = \sum \vec{p}_f$, if there are no external forces

Moment of inertia for a point mass: $I = mr^2$
Moment of inertia for a disk or cylinder, about its center: $I = \frac{1}{2}mr^2$
(other shapes will be given to you if required)

Angular momentum: $L = I\omega$; for a point mass, you can also write $L = mv_T r$
Conservation of angular momentum: $L_i = L_f$, if there are no external torques

For rockets: (thrust) = (gas flow rate) $\times$ (exhaust velocity)

Definition of a newton: 1 N = 1 kg m/s^2

Forces we have studied:

- Normal force: contact force between objects. Can only push, never pull.
- Gravity: mg downward on Earth, $\frac{GMm}{r^2}$ in general, where r is the distance between the objects' centers
- Static friction: keeps objects which are in contact from sliding; maximum value $F_{\text{f,max}} = \mu_s F_N$. Traction is a special case of static friction.
- Kinetic friction: opposes the relative motion of two surfaces in contact. $F_f = \mu_k F_N$.
- Tension: force that ropes exert on things. Can only pull, never push.