Physics Notes

Matthew Stringer

Contents

1 Rotational Motion

1.1 Rotational Kinematics

1.1.1 Linear vs Angular Velocity

- Linear speed given by v
- Angular speed given by ω
- Direction is perpendicular to the path based on right hand rule

1.1.2 Converting Linear to angular velocity

$$v = r\frac{d\theta}{dt} = r\omega$$
$$\omega = \frac{v}{r}$$

1.1.3 Linear vs Angular acceleration

- Linear acceleration given by a
- Angular acceleration given by α

1.1.4 Centripetal Acceleration

$$a = -\frac{v^2}{r}$$

1.2 Moment of Inertia

1.2.1 Types of Inertia

- Inertial mass (linear inertia) is an object's ability to resist linear acceleration.
- Moment of Inertia (rotational inertia) is an object's ability to resist rotational acceleration.

1.2.2 Kinetic Energy of Rotating Disk

$$K_{TOT} = \frac{\omega^2}{2}\int_0^r r^2 dr = \frac{1}{2}J\omega^2$$

1.2.3 Common Moments of Inertia

- Disk: $I = \frac{1}{2}mr^2$
- Hoop: $I = ml^2$
- Sphere: $I = \frac{2}{5}mr^2$
- Hollow Sphere: $I = \frac{2}{3}mr^2$
- Rod(around center point): $I = \frac{1}{12}ml^2$
- Rod(around end point): $I = \frac{1}{3}ml^2$

1.3 Torque

$$\tau = r \times F$$
$$|\tau| = rF\sin\theta$$

1.3.1 Direction of Torque Vector

- Torque vector is perpendicular to both force and position vector
- Use the right hand rule
- Positive Torques cause counter-clockwise rotations

1.3.2 Translational vs Rotational

$$F = ma \quad \tau = I\alpha$$

1.4 Rotational Dynamics

1.4.1 Kinetic Energy

$$K_{rotational} = \frac{1}{2}Iw^2$$

1.5 Angular Momentum (L)

$$L_Q = r \times p = (r \times v)m$$

where r is a vector from point Q to the force.
Spin Angular Momentum is the angular momentum around the center of mass. This type of angular momentum is not based off of a reference point.

2 Oscillations

2.1 General Form of Simple Harmonic Motion

$$\ddot{x} + \omega^2 x = 0$$

which evaluates to

$$x(t) = A\cos(\omega t + \phi)$$