PHY180 Torque

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1 Chapter 4,5:

Coefficient of restitution, **e**:

$$e = \frac{v_{12f}}{v_1 2i}$$

Fully elastic collision:

$$V_{1,f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1,i} + \frac{2m_2}{m_1 + m_2} v_{2,i}$$

General Partially Inelastic Collison:

$$v_1 = \frac{em_2(v_{2,\mathrm{i}} - v_{1,\mathrm{i}}) + m_1 v_{1,\mathrm{i}} + m_2 v_{2,\mathrm{i}}}{m_1 + m_2}$$

*if some % of kinetic energy is lost, say 10%, then e = $\sqrt{0.9}$

2 Chapter 6: Relativity

Position of center of mass:

$$\overrightarrow{r_{cm}} = \frac{m_1 \overrightarrow{r}_1 + m_2 \overrightarrow{r}_2 ...}{m_1 + m_2}$$

Velocity of center of mass: **(also velocity of zero momentum reference frame)**:

$$\overrightarrow{v_{cm}} = \frac{m_1 \overrightarrow{v}_1 + m_2 \overrightarrow{v}_2 ...}{m_1 + m_2}$$

Transnational (nonconvertible) kinetic energy of a system (K_{cm}):

$$K_{cm} = \frac{1}{2} m_{total} v_{cm}^2$$

For a two particle system, the convertible kinetic energy is:

$$K_{conv} = \frac{1}{2} \mu v_{12}^2$$

where the reduced mass, μ:

$$\mu = \frac{m_1 m_2}{m_1 + m_2}$$

Changes in the momentum and energy of a system are the same in any two inertial reference frames.

3 Chapter 7: Interactions

If two objects with inertia's m_1 and m_2 interact, the ratio of the x components of their accelerations is:

$$\frac{a_{1x}}{a_{2x}} = -\frac{m_2}{m_1}$$

(acceleration ratio inversely proportional to mass ratio).

The **potential energy, U = U(x)** is a function of position x, that describes the potential energy available to the system at that position state.

4 Chapter 8: Force

Spring force:

$$F_{\text{by spring on load}_x} = -k(x - x_0)$$

where x_0 is the position of the uncompressed spring at rest.

$$\sum \overrightarrow{F} = m\overrightarrow{a}$$

For two interacting objects:

$$\overrightarrow{F_{12}} = -\overrightarrow{F_{21}}$$

Impulse, $\overrightarrow{J}$: Constant force(s):

$$\Delta\overrightarrow{p} = \overrightarrow{J} = (\sum \overrightarrow{F})\Delta t$$

Time varying force(s):

$$\Delta\overrightarrow{p} = \overrightarrow{J} = \int_{t_i}^{t_f} \sum \overrightarrow{F}(t)dt$$

The center of mass of a system of objects accelerates as though all the objects were located at the center of mass and the external force were applied at that location.

$$\overrightarrow{a}_{cm} = \frac{\sum \overrightarrow{F}_{ext}}{m_{\text{total}}}$$

5 Chapter 9: Work

For a constant force:

$$W = (\sum F_x)\Delta x_F$$

i.e.:

$$W = F \cdot d$$

For a distance-varying force, let's call x the distance, given:

$$F(x)$$

work is now:

$$W = \int_{x_i}^{x_f} F(x)dx$$

If the free end of a spring is displaced from its relaxed position x_0 to position x, the change in its potential energy is:

Power is the rate at which energy changes forms, or is transferred.

$$P = \frac{dE}{dt}$$

If a constant external force F is exerted on an object and the component of the velocity at the point where the force is applied isv_x, the power this force delivers to the object is:

$$P = F \cdot v_x$$

6 Everything Else:

6.1 Rotational Inertia:

Point mass a distance r from pivot:

$$I = mr^2$$

Parallel axis theorem:

$$I_{\text{total}} = I_0 + md^2$$

$$\text{Angular Momentum, J} = I\omega$$

or, the angular momentum of some point mass of inertia m, which is a distance of r from a pivot, traveling at a tangential velocity of v:

$$J = mvr$$

$$\text{Tangential Velocity, } v_t = r\omega$$

$$\text{x quantity} = r \cdot \text{rotational quantity}$$

$$K_{\text{rotational}} = \frac{1}{2} I\omega^2$$

$$\alpha_{\text{(rotational acceleration)}} = \frac{\tau}{I}$$

$$a_r = -r\omega^2$$

For an object rolling down some ramp, the rotational energy at the bottom:

$$K_{\text{rotational}} = mgh \left(\frac{1}{1 + \frac{1}{c}} \right)$$

Relationship between coefficient of friction, μ and the angle of inclination θ for an object rolling down an incline:

$$\tan(\theta) = \mu(1 + \frac{1}{c})$$

Relationship of frequency and period:

$$\omega = \frac{2\pi}{T}$$