

Exam 2 Review

Chapter 6: Conservation of Energy

Introduce and apply one of the most important principles in physics.

- **The Law of Conservation of Energy**
One of the few universal laws of physics.
Energy can be in many different forms.
 - Kinetic energy is due to motion.
 - Potential energy is due to interactions.
 - Rest energy from Einstein's $E = mc^2$.
- **Work Done by a Constant Force**

$$W = F \Delta r \cos \theta$$

Work can be positive, negative, or zero.

- **Kinetic Energy**
For translational motion

$$K = \frac{1}{2} mv^2$$

The total work done changes the kinetic energy

$$W_{total} = \Delta K$$

- **Gravitational Potential Energy (1)**

$$U_{grav} = mgy$$

Choose the zero of potential energy at some convenient height.
The all important conservation of energy theorem is

$$W_{nc} = \Delta K + \Delta U$$

or

$$(K_i + U_i) + W_{nc} = (K_f + U_f)$$

The mechanical energy is

$$E_{mech} = K + U$$

- **Gravitational Potential Energy (2)**
Found from Newton's law of gravity.

$$U = -\frac{Gm_1m_2}{r}$$

- **Work Done by Variable Forces: Hooke's Law**

Hooke's law for the force due to an ideal spring

$$F_x = -kx$$

- **Elastic Potential Energy**

$$U_{elastic} = \frac{1}{2}kx^2$$

- **Power**

$$P_{av} = \frac{\Delta E}{\Delta t}$$

Instantaneous power

$$P = Fv \cos \theta$$

Chapter 7: Linear Momentum

A conservation theorem that involves vectors.

- **A Conservation Law for a Vector Quantity**

We take components of vectors.

- **Momentum**

$$\vec{p} = m\vec{v}$$

- **The Impulse-Momentum Theorem**

The change in momentum is caused by the impulse

$$\Delta\vec{p} = \sum \vec{F}\Delta t$$

Newton's second law can be reformulated

$$\sum \vec{F} = \lim_{\Delta t \rightarrow 0} \frac{\Delta\vec{p}}{\Delta t}$$

- **Conservation of Momentum**

If the net external force acting on a system is zero, momentum is conserved.

- **Center of Mass**

$$x_{CM} = \frac{\sum m_i x_i}{M} \quad y_{CM} = \frac{\sum m_i y_i}{M}$$

- **Motion of the Center of Mass**

Newton's second law holds for extended objects

$$\sum \vec{F}_{ext} = M\vec{a}_{CM}$$

- **Collisions in One Dimension**

- Elastic.

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2} \right) v_{1i} + \left(\frac{2m_2}{m_1 + m_2} \right) v_{2i}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2} \right) v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2} \right) v_{2i}$$

- Inelastic
- Perfectly inelastic.

$$v_{1f} = v_{2f}$$

- **Collisions in Two Dimensions**

Draw pictures of initial and final situation. Use components of momenta.

Chapter 7: Torque and Angular Momentum

Discuss the dynamics of rotational motion and its similarity to translational motion.

- **Rotational Kinetic Energy and Rotational Inertia**

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

$$I = \sum_{i=1}^N m_i r_i^2$$

The rotational inertia of many uniform shapes has been determined.

- **Torque**

$$\tau = \pm r F_{\perp} = \pm r_{\perp} F$$

The sign is determined by counterclockwise (+) or clockwise (-).

- **Calculating Work Done From the Torque**

$$W = \tau \Delta\theta$$

- **Rotational Equilibrium**

$$\sum \vec{\mathbf{F}} = 0 \text{ and } \sum \tau = 0$$

A clever choice of the axis for the torque equation can simplify the problem.

- **Equilibrium in the Human Body**

The forces in the body are surprisingly large.

- **Rotational Form of Newton's Second Law**

$$\sum \tau = I\alpha$$

- **The Motion of Rolling Objects**

$$\begin{aligned} K &= K_{trans} + K_{rot} \\ &= \frac{1}{2}mv_{CM}^2 + \frac{1}{2}I_{CM}\omega^2 \end{aligned}$$

- **Angular Momentum**

$$L = I\omega$$

$$\sum \tau = \frac{dL}{dt}$$

If the torque is zero, angular momentum is conserved.

- **The Vector Nature of Angular Momentum**

The direction is given by the right-hand rule.