Summary

C2: Introduction to Momentum

- Interactions: contact and long-range
- $$\text{speed} \equiv \frac{\Delta r}{\Delta t} \, . \tag{1}$$
- $$\vec{\text{momentum}} \equiv m\vec{v} \tag{2}$$
- Weight vs. mass

C3: Vectors

- Vectors have magnitude and direction
- $$mag(\vec{v}) = \sqrt{v_x^2 + v_y^2 + v_z^2} \, . \tag{3}$$
- Scalar: number without direction
- Converting from magnitude and direction to components, and vice-versa
- Adding vectors
- Scalar Multiplication

C4: Particles and Systems

- Displacement Vectors
- $$\Delta\vec{r} = \vec{r_2} - \vec{r_1} \, . \tag{4}$$

- $$\vec{v} \equiv \frac{\Delta \vec{r}}{\Delta t} \, . \tag{5}$$
- Interactions transfer momentum
- Momentum is conserved if the system is isolated
- Center of mass
- Motion of center of mass is in a straight line if no external interactions.

C5: Applying Momentum Conservation

- Applications of momentum conservation
- Earth is big, we are small
- Frictionless vs. Friction

C6: Introduction to Energy

- Kinetic energy increases with speed and mass, and is a quantity associated with an object's motion
- Potential energy = potential to have kinetic energy
- Potential energies are associated with a position or separation
- Total energy = Kinetic energy + potential energy
- Gravitational Potential energy $\equiv mgz$. Formula valid only near the surface of the earth.
- Energy of a closed system is conserved.
- One Joule $\equiv$ kgm/s^2.

C7: Potential Energy Functions

- Potential energy due to the gravitational interaction:

$$V(r) \;=\; \frac{-GMm}{r}\;. \tag{6}$$

- Potential energy due to the spring interaction

$$V(x) \;=\; \frac{1}{2}k_x x^2\;. \tag{7}$$

C8: Energy Transfers

- The dot product
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$$\vec{u}\cdot\vec{w} \;\equiv\; uv\cos\theta\;, \tag{8}$$

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$$\vec{u}\cdot\vec{w} \;=\; u_x w_x + u_y w_y + u_z w_z\;. \tag{9}$$

- Energy Transfer (Work):

$$dK \;=\; vdp\cos\theta \tag{10}$$

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$$dK \;= \tag{11}$$

- $\vec{\text{Force}} = \frac{\Delta\vec{p}}{\Delta t}$.
- Gravitational force: $F_z = -mg$.