

Midterm 3 for Calculus-Based Physics-1: Mechanics (PHYS150-O1)

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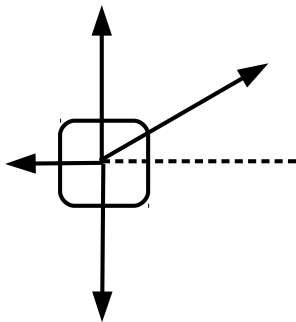
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1 Definition of Work

1. In each of the following three questions, determine whether work is being performed **on the backpack**.

- A student lifts her backpack. (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase **(b)**
- A student lowers her backpack. (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase **(c)**
- A student walks horizontally with her backpack at constant height (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase **(a)**

2. For this problem, use the work formula $W = \vec{F}_{\text{Net}} \cdot \vec{x}$, where \vec{F}_{Net} is the net force on a system that is moved a displacement \vec{x} . (a) Draw the correct free-body diagram for a crate being pushed horizontally against friction by some applied force \vec{F} , which makes a 30 degree angle with the horizontal.



(b) Calculate the work done on the the system if the mass is 100 kg, $\vec{x} = 1\hat{i}$ m, the friction force is $-100\hat{i}$ N, and the magnitude of \vec{F} is 400 N. **Solution:** The net force in the x-direction (the direction of the displacement) is $-100 + 200\sqrt{3}$ N, so the force times the displacement is $100(2\sqrt{3} - 1)$ J.

2 Kinetic Energy

1. What is the kinetic energy of a system with mass 2 kg moving at $\sqrt{10}$ m/s? **Solution:** $KE = \frac{1}{2}mv^2 = \frac{1}{2}(2)(\sqrt{10})^2 = 10$ J.
2. What would be the kinetic energy if the speed doubled? **Solution:** Kinetic energy is proportional to the square of the speed, so if we double speed the kinetic energy quadruples: $KE = 40$ J. *This is an example of a **scaling** problem.*

3 Work-Energy Theorem

1. How much work is required to compress a spring with spring constant $k = 500$ N/m by a displacement 0.1 m? How high will an object go if we use the spring to shoot something straight up, if it has 0.1 kg mass? **Solution:** $W_s = \frac{1}{2}kx^2 = \frac{1}{2}(500)(0.1)^2 = \frac{5}{2}$ J. As for the height, we can solve it kinematically, but it's much easier to use gravitational potential energy: $PE = mgh$, so $\frac{5}{2} = 0.1 * 10h$, or $h = \frac{5}{2}$ m.

4 Gravitational Potential Energy

1. What is the maximum velocity achieved by an object if we drop it from 300 m? (No drag). **Solution:** Set gravitational potential energy equal to kinetic energy and solve for speed: $PE = KE$, so $mgh = \frac{1}{2}mv^2$, or $v = \sqrt{2gh} = \sqrt{2 * 10 * 300} = \sqrt{6000}$ m/s (about 80 m/s).

5 Conservative Forces

1. Be able to describe, in your own words, what is a conservative force. Which of these forces is conservative?
(a) Friction, kinetic (b) Drag, air (c) Stoke's Law (drag in viscous liquids) (d) Hooke's Law