Midterm 3 for Calculus-Based Physics-1: Mechanics (PHYS150-01)

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1 Definition of Work

1. *In each of the following three questions, determine whether work is being performed* ***on the briefcase***.
   - A man is walking horizontally, carrying a briefcase at a constant height. (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase
   - A man stands still, and holding a briefcase in a fixed position. (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase
   - A man stands still, and lowers the briefcase to a height less than the original height. (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase
   - A man raises the briefcase to a height greater than the original height. (a) No work is done on briefcase (b) Positive work is done on briefcase (c) Negative work is done on briefcase
2. For this problem, use the work formula $W = \vec{F} \cdot \vec{x}$, where $\vec{F}$ is a constant applied 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 the applied force $\vec{F}$. (b) Calculate the work in Joules required to move a 200 kg palette crate a distance of 10 m on a surface with coefficient of kinetic friction of 0.05.

3. A crane lifts a shipping container from a ship to the dock. The shipping container is at a height of 30 meters above the water initially, and ends 4 meters above the water after the move is complete. The shipping container has a mass of 4500 kg. (a) Draw the correct free-body diagram. (b) What is the work done on the shipping container, in kJ? Should it be positive or negative?

2 Kinetic Energy

1. In a particular radioactive isotope, *thermal neutrons* are emitted with kinetic energy $KE = \frac{1}{2}mv^2$. If the mass of a neutron is 1.7×10^{-27} kg, and the velocity is $v = 3 \times 10^6$ m/s, (a) what is the kinetic energy? (b) If 1 electron-Volt equals 1.6×10^{-19} Joules, how many electron-Volts of energy do these neutrons have?

2. Not every particle in the radiation is a neutron. Suppose one is an *alpha-particle*, which has four times the mass of a neutron. If we detect an alpha particle that has the same speed as a neutron, and the neutron has kinetic energy of 5 MeV (5×10^6 electron-Volts), what is the kinetic energy of the alpha particle?

3 Work-Energy Theorem

1. An archer's bow acts like a spring with a spring constant of $k = 350$ N/m. If an arrow is loaded into this bow, how much energy is required to draw it back 0.5 m?

    - 4 J
    - 40 J
    - 400 J
    - 4000 J

2. Assume all of the energy in the drawn bow in the previous question is released into the kinetic energy of the arrow (mass = 0.02 kg). If the arrow is fired from a height of 1.5 m, how far does it travel before it lands?

    - 3 m
    - 30 m
    - 300 m
    - 3000 m

4 Gravitational Potential Energy

1. The height of Freedom Tower in New York City is 1776 feet, or or 541 meters. Suppose we drop a penny off of the top! (a) What is the *potential energy* in J before we drop it, if it has a mass of 2.5 grams?

    - 1.35 J
    - 13.5 J
    - 27 J
    - 54 J

    (b) What velocity does the penny have when it hits the street, assuming no drag force?

    - 1 m/s
    - 10 m/s
    - 100 m/s
    - 300 m/s

5 Conservative Forces

1. (a) Which of these forces is *conservative*?

    - The spring force (Hooke's Law)
    - Kinetic friction
    - Drag due to air
    - Stoke's Law (drag in viscous substances)

    (b) In your own words, define a *conservative* force.