Homework 8

Aaron W. Tarajos
October 14, 2024

Problem 1

A 0.315-kg particle moves from an initial position $\vec{\mathbf{r}}_1 = 2.00\,\hat{\mathbf{i}} - 1.00\,\hat{\mathbf{j}} + 3.00\,\hat{\mathbf{k}}$ m to a final position $\vec{\mathbf{r}}_2 = 4.00\,\hat{\mathbf{i}} - 3.00\,\hat{\mathbf{j}} - 1.00\,\hat{\mathbf{k}}$ m while a force $\vec{\mathbf{F}} = 2.00\,\hat{\mathbf{i}} - 3.00\,\hat{\mathbf{j}} + 1.00\,\hat{\mathbf{k}}$ N acts on it. What is the work done by the force on the particle?

Solution

The distance traveled by the particle, $\vec{\mathbf{d}}$, is equal to the difference in final and initial position

$$\begin{aligned}\vec{\mathbf{d}} &= \vec{\mathbf{r_2}} - \vec{\mathbf{r_1}} \\ &= (4.00 - 2.00)\ \hat{\mathbf{i}} + (-3.00 + 1.00)\ \hat{\mathbf{j}} + (-1.00 - 3.00)\ \hat{\mathbf{k}} \\ &= 2.00\,\hat{\mathbf{i}} - 2.00\,\hat{\mathbf{j}} - 4.00\,\hat{\mathbf{k}}\end{aligned}$$

Then work is the dot product of $\vec{\mathbf{F}}$ and $\vec{\mathbf{d}}$

$$W = \vec{\mathbf{F}} \cdot \vec{\mathbf{d}} = (2)(2) + (-2)(-3) + (-4)(1) = \boxed{6\text{ J}}$$

Problem 2

Compute the kinetic energy for each of the cases below. Through what distance would a 800-N force have to act to stop each object?
(a) A 150-g baseball moving at 40 m/s;
(b) a 13-g bullet from a rifle moving at 635 m/s;
(c) a 1500-kg Corvette moving at 250 km/h;
(d) a 1.8×10^5-kg Concorde airliner moving at 2240 km/h.

Solution

The kinetic energy is given by

$$k = \frac{1}{2}mv^2 \tag{1}$$

Then

$$k = Fd \implies d = \frac{k}{F}$$

Using these equations to solve for each part;

Part a:

$$k = \frac{1}{2}(150)(40)^2 = \boxed{120\,000\text{ J}}$$

and

$$d = \frac{120\,000}{800} = \boxed{150\text{ m}}$$

Part b:

$$k = \frac{1}{2}(13)(635)^2 = \boxed{2.62 \times 10^6 \text{ J}}$$

and

$$d = \frac{2.62 \times 10^6}{800} = \boxed{3276.20 \text{ m}}$$

Problem 3

Compute the kinetic energies for each of the following. What force would be required to stop each object in 1.00 km?
(a) The 8.00×10^7-kg carrier Nimitz moving at 55 km/h;
(b) a 3.4×10^5-kg Boeing 747 moving at 1000 km/h;
(c) the 270-kg Pioneer 10 spacecraft moving at 51,800 km/h.

Problem 4

A 1.50-kg block is moved at constant speed in a vertical plane from position 1 to position 3 via several routes shown in the figure. Compute the work done by gravity on the block for each segment indicated, where W_{ab} means work done from a to b.
(a) W_{13}
(b) $W_{12} + W_{23}$
(c) $W_{14} + W_{43}$
(d) $W_{14} + W_{45} + W_{53}$

Problem 5

What is the work needed to lift 14.7 kg of water from a well 11.0 m deep. Assume the water has a constant upward acceleration of 0.700 m/s^2.

Problem 6

The variation of a force with position is shown in the figure below. Find the work from (a) $x = 0$ to $x = -A$
(b) $x = +A$ to $x = 0$

Problem 7

Consider a particle on which several forces act, one of which is known to be constant in time: $\vec{\mathbf{F}}_1 = 3.00\,\hat{\mathbf{i}} + 4.00\,\hat{\mathbf{j}}$ N. As a result, the particle moves along a straight path from a Cartesian coordinate of (0.00 m, 0.00 m) to (5.00 m, 6.00 m). What is the work done by $\vec{\mathbf{F}}_1$?

Problem 8

A bungee cord exerts a nonlinear elastic force of magnitude $F(x) = k_1 x + k_2 x^3$, where x is the distance the cord is stretched, $k_1 = 204$ N/m and $k_2 = -0.233$ N/m^3. How much work must be done on the cord to stretch it 16.7 m?