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NCTC PHYS 2425

March 3, 2024

Chapter 7 Homework

Questions

11. If the speed of a particle doubles, by what factor does its kinetic energy increase?

$$k = \frac{1}{2}mv^2 \rightarrow k = \frac{1}{2}m(2v)^2 \rightarrow k = \frac{1}{2}m(2)^2(v)^2 \rightarrow k = \frac{1}{2}m(4)(v)^2$$

Because kinetic energy is exponentially related to velocity, the kinetic energy of a particle, for which speed doubles, would quadruple. There was an interesting example of this phenomenon demonstrated in class, in which the distance to stop a car was compared for various speeds.

Misconception Questions

2. You are carrying a 10-kg bag and moving at constant speed. In which case will you do the most work on the bag?

(d) Climb up a 5-m-tall slope.

5. If you push twice as hard against a stationary brick wall, the amount of work you do

(d) is zero.

7. A delivery man carrying a package walks up the stairs to the second floor at constant speed (A), and along the hall at a constant speed (B). He accelerates to a run and then moves at a greater constant speed along the hall. During what portions of his motion is the delivery man doing work on the package? (ignore friction)

(b) C only.

Problems

1. How much work is done by gravitational force when a 280-kg pile driver falls 3.80m?

Earth's mass and radius are $m_E = 5.98 \times 10^{24} kg$ and $r_E = 6.38 \times 10^6 m$

$$W = F_{||} d \qquad F_G = G\frac{m_1 m_2}{r^2}$$

$$F_G = G\frac{m_E m_P}{(r_E + 3.80)^2}$$

$$F_G = (6.67 \times 10^{-11} N\frac{m^2}{kg^2})\frac{(5.98 \times 10^{24} kg)(280 kg)}{(6.38 \times 10^6 m + 3.80m)^2}$$

$$W = (2743N)(3.80m) \qquad F_G = 2743.74N$$

$$W = 10426J$$

$$W = 1.0 \times 10^4 J$$

3. A 55.0-kg firefighter climbs a flight of stairs 28.0 m high at constant speed. How much work does she do?

$$W = F_{||} d \qquad \Sigma F_y = F_H - mg = 0$$

$$F_H = mg$$

$$W = mgd$$

$$W = (55.0kg)(9.8m/s^2)(28.0m)$$

$$W = 15092J$$

$$W = 1.5 \times 10^4 J$$

18. What is the dot product of $\vec{A} = 2.0x^2\hat{i} - 4.0x\hat{j} + 5.0\hat{k}$ and $\vec{B} = 11.0\hat{i} + 2.5x\hat{j}$?

$$\begin{aligned} \vec{A} \cdot \vec{B} &= A_x B_x + A_y B_y + A_z B_z \\ &= (2.0x^2)(11.0) + (-4.0x)(2.5x) + (5.0)(0) \\ &= 22x^2 - 10x^2 + 0 \\ &= 12x^2 \end{aligned}$$

24. A constant force $\vec{F} = (2.0\hat{i} + 4.0\hat{j})N$ acts on an object as it moves along a straight-line path. If the object's displacement is $\vec{d} = (1.0\hat{i} + 5.0\hat{j})m$, calculate the work done by $\vec{F}$ using these alternate ways of writing the dot product:

(a) $W = Fdcos\Theta$

$$= \left(\sqrt{(2.0)^2 + (4.0)^2} N\right)(5.0m)$$

$$W = 22J$$

(b) $W = F_x d_x + F_y d_y$

$$= (2.0N)(1.0m) + (4.0N)(5.0m)$$

$$W = 22J$$

29. Let $\vec{V} = 20.0\hat{i} + 26.0\hat{j} - 14.0\hat{k}$. What angles does this vector make with the x, y, and z axes?

$$R = \sqrt{(20.0)^2 + (26.0)^2 + (-14.0)^2} = 35.7$$
$$\Theta_x = arccos\frac{20.0}{35.7} = 55.9°$$
$$\Theta_y = arccos\frac{26.0}{35.7} = 43.2°$$
$$\Theta_z = arccos\frac{-14.0}{35.7} = 113°$$

37. A spring has $k = 65N/m$. Draw a graph like that in Fig. 7-11 and use it to determine the work needed to stretch the spring from $x = 3.02cm$ to $x = 7.5cm$, where $x = 0$ refers to the spring's unstretched length.

$$W = \frac{1}{2}kx^2$$
$$W_1 = \frac{1}{2}(65N/m)(0.0302m) \qquad W_2 = \frac{1}{2}(65N/m)(0.075m)$$
$$W_1 = 0.9815J \qquad W_2 = 2.4375J$$
$$W_2 - W_1 = 1.5J$$

39. The net force exerted on a particle acts in the positive x direction. Its magnitude increases linearly from zero at $x = 0$, to $380N$ at $x = 3.0m$. It remains constant at $380N$ from $x = 3.0m$ to $x = 7.0m$, and then decreasees linearly to zero at $x = 12.0m$. Determine the work done to move the particle from $x = 0$ to $x = 12.0m$ graphically, by determining the area under the F_x versus x graph.

$$W = \frac{1}{2}(380N)(3.0m) + (380N)(4.0m) + \frac{1}{2}(380N)(5)$$
$$W = 3040J$$

56. How much work is required to stop an electron $(m = 9.11 \times 10^{-31}kg)$ which is moving with a speed of $1.10 \times 10^6 m/s$?

$$W = \frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2$$
$$W = \frac{1}{2}(9.11 \times 10^{-31}kg)(1.10 \times 10^6 m/s)^2 - 0$$
$$W = 5.51 \times 10^{-19}J$$

62. At an accident scene on a level road, investigators measure a car's skid mark to be 78m long. It was a rainy day and the coefficient of friction was estimated to be 0.30.

(a) Use these data to determine the speed of the car when the driver slammed on (and locked) the brakes.

$$\begin{aligned} \Sigma F_x = 0 - F_{fr} &= ma \\ -\mu F_N &= ma \\ -\mu mg &= ma \\ -\mu g &= a \end{aligned} \qquad \begin{aligned} \Sigma F_y = F_N - mg &= 0 \\ F_N &= mg \end{aligned}$$

$$\begin{aligned} v_f^2 &= v_0^2 + 2a\Delta x \\ v_f^2 &= v_0^2 + 2(^{-}\mu g)\Delta x \\ v_0 &= \sqrt{2\mu g \Delta x} \\ v_0 &= \sqrt{2(0.30)(9.8m/s^2)(78m)} \\ v_0 &= 21.4m/s \end{aligned}$$

(b) Why does the car's mass not matter?

The mass of the car is included in each of the sumation of force equations. When these equations are substitued into one another, the mass is algebraically irrelevant.

(c) What is wrong with a car that skids (see page 131)?

The car which skids is losing traction. Maybe the vehicle-owner needs new tires on his old Corolla! And the car may have faulty Anti-lock-braking.

74. Spiderman uses his spider webs to save a runaway train moving about $60km/h$. His web stretches a few city blocks ($500m$) before the $10^4 kg$ train comes to a stop. Assuming the web acts like a spring, estimate the effective spring constant.

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