Problem 1

A spring gun with k = 90.0 N/m is compressed by 5 cm. What is the exit speed of a 2.10-g projectile?

Solution

$$
\begin{aligned}
W &= \int_{min}^{max} F(x)\ dx = \int_{-0.05}^{0} -kx\ dx = \left(-\frac{1}{2}kx^2\right) |_{-0.05}^{0} \\
&= \frac{1}{2}k * 0.05^2 = 45\text{N/m} * 0.0025\text{m}^2 = 0.1\text{J} \\
W &= \Delta K = K_f - K_i
\end{aligned}
$$

Since the spring on the block is unmoving at the start, then $v_i = 0$, so $K_i = \frac{1}{2}mv_i^2$ is also equal to zero. From there, we can determine the final kinetic energy and determine the velocity at the end.

$$
\begin{aligned}
K_f &= W = 0.1\text{J} = \frac{1}{2}mv_f^2 \\
\frac{2K_f}{m} &= v_f^2 \\
v_f &= \sqrt{\frac{2K_f}{m}} = \sqrt{\frac{2 * 0.1\text{J}}{0.0021\text{kg}}} = \sqrt{\frac{2 * 1000}{21}} \\
&= \boxed{\frac{20\sqrt{105}}{21}\text{m/s} \approx 9.759\text{m/s}}
\end{aligned}
$$

Problem 2

(a) The United States, with a population of 2.2×10^8 people, consumes 5×10^{19} J per year. What is the per capita consumption in watts? (b) The sun's radiation provides the earth with 1000 W/m^2. Assuming solar energy can be converted to electrical energy with a 20% efficiency, how much area is needed to serve the energy needs of each U.S. citizen?

Solution

Section (a)

The power is determined by the work (W) divided by the time, with a watt being a joule divided by a second. The per capita value is determined by division by the number of humans (c). Assuming a year of 365 days, we can calculate the number of seconds per year (t) first.

$$\begin{aligned}
t &= 1 \text{ years} * \frac{365 \text{ days}}{1 \text{ years}} * \frac{24 \text{ hours}}{1 \text{ days}} * \frac{3600\text{s}}{1 \text{ hours}} = 31536 \times 10^3\text{s} \\
P &= \frac{W}{t} = \frac{5 \times 10^{19}\text{J}}{(31536 \times 10^3\text{s})} = \frac{5 \times 10^{16}}{31536}\text{W} \\
&= 1.58549 \times 10^{12} \text{ W} \\
P_{per\ captia} &= \frac{1.58549 \times 10^{12}}{2.2 \times 10^8}\text{W} \\
&= \boxed{7206.77\text{W}}
\end{aligned}$$

Section (b)

Since there is only a 20% efficiency, the usable numbers of watts per square meter would be $Wa = 1000 \text{ W/m}^2 * \frac{20}{100} = 200 \text{ W/m}^2$. We can divide the total power necessary per citizen (which we calculated in part (a)) to get the area necessary.

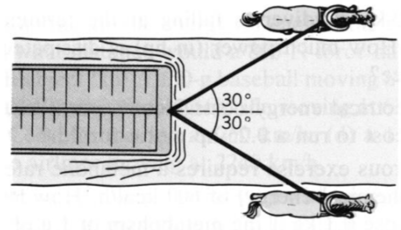
$$A = \frac{P}{Wa} = \frac{7206.77\text{W}}{200 \text{ W/m}^2} = \boxed{36.03\text{m}^2}$$

Problem 3

A 0.595-kg object is released from a height of 3.60 m and lands on the ground. Find: (a) the work done by gravity; (b) the change in kinetic energy of the ball; (c) the speed just before it lands using energy methods. Ignore air resistance.

Solution

Problem 4



Two horses pull a barge along a canal at a steady 5.00 km/h, as shown in the figure. The tension in each rope is 420 N and each is at 300 to the direction of motion. What is the horsepower provided by the horses?

Solution