Work and Energy

Additional Practice F

Givens	*Solutions*
1. $P = 380.3$ kW $W = 4.5 \times 10^6$ J	$\Delta t = \frac{W}{P} = \frac{4.5 \times 10^6 \text{ J}}{380.3 \times 10^3 \text{ W}} = \boxed{12 \text{ s}}$
2. $P = 331$ W $h = 442$ m $m = 55$ kg $g = 9.81 \text{ m/s}^2$	$W = mgh$ $\Delta t = \frac{W}{P} = \frac{mgh}{P} = \frac{(55 \text{ kg})(9.81 \text{ m/s}^2)}{331 \text{ W}} = \boxed{720 \text{ s} = 12 \text{ min}}$
3. $F = 334$ N $d = 50.0$ m $\theta = 0°$ $P = 2100$ W	$W = Fd(\cos\theta)$ $\Delta t = \frac{W}{P} = \frac{Fd(\cos\theta)}{P} = \frac{(334 \text{ N})(50.0 \text{ m})(\cos 0°)}{2100 \text{ W}} = \boxed{7.95 \text{ s}}$
4. $P = 13.0$ MW $\Delta t = 15.0$ min	$W = P\,\Delta t = (13.0 \times 10^6 \text{ W})(15.0 \text{ min})(60 \text{ s/min}) = \boxed{1.17 \times 10^{10} \text{ J}}$
5. $P = 1$ hp $= 745.7$ W $\Delta t = 0.55$ s	$W = P\,\Delta t = (745.7 \text{ W})(0.55 \text{ s}) = \boxed{4.1 \times 10^2 \text{ J}}$
6. $P = (4)(300.0 \text{ kW})$ $\Delta t = 25$ s	$W = P\,\Delta t = (4)(300.0 \times 10^3 \text{ W})(25 \text{ s}) = \boxed{3.0 \times 10^7 \text{ J}}$
7. $\Delta t = 39$ s $P = 158$ kW	$W = P\,\Delta t = (158 \times 10^3 \text{ W})(39 \text{ s}) = \boxed{6.2 \times 10^6 \text{ J}}$
8. $W = 1.4 \times 10^{13}$ J $\Delta t = 8.5$ min	$P = \frac{W}{\Delta t} = \frac{1.4 \times 10^{13} \text{ J}}{(8.5 \text{ min})(60 \text{ s/min})} = \boxed{2.7 \times 10^{10} \text{ W} = 27 \text{ GW}}$
9. $W = 2.82 \times 10^7$ J $\Delta t = 30.0$ min	$P = \frac{W}{\Delta t} = \frac{2.82 \times 10^7 \text{ J}}{(30.0 \text{ min})(60 \text{ s/min})} = \boxed{1.57 \times 10^4 \text{ W} = 15.7 \text{ kW}}$ $P = (1.57 \times 10^4 \text{ W})(1 \text{ hp}/745.7 \text{ W}) = \boxed{21.1 \text{ hp}}$
10. $W = 3.0 \times 10^6$ J $\Delta t = 5.0$ min	$P = \frac{W}{\Delta t} = \frac{3.0 \times 10^6 \text{ J}}{(5.0 \text{ min})(60 \text{ s/min})} = \boxed{1.0 \times 10^4 \text{ W}}$

Work and Energy

Problem F

POWER

PROBLEM

The engines of the *Queen Mary* could deliver 174 MW to propel the massive ship. How long does it take for the engines to do 7.31×10^{10} J of work on the ship?

SOLUTION

Given: $P = 174$ MW

$W = 7.31 \times 10^{10}$ J

Unknown: $\Delta t = ?$

Use the equation for power and rearrange it to solve for time.

$$P = \frac{W}{\Delta t}$$

$$\Delta t = \frac{W}{P} = \frac{7.31 \times 10^{10}\ \text{J}}{174 \times 10^{6}\ \text{W}} = \boxed{4.20 \times 10^{2}\ \text{s}}$$

$$\Delta t = (4.20 \times 10^{2}\ \text{s})(1\ \text{min}/60\ \text{s}) = \boxed{7.00\ \text{min}}$$

ADDITIONAL PRACTICE

1. The engine that moves the cables for the San Francisco cable cars delivers 380.3 kW of power for each line. How long does it take for 4.5×10^{6} J of work (about the amount of work needed to raise a partially loaded cable car up Nob Hill) to be done by this engine?
2. If the stairs of the Sears Tower in Chicago, Illinois, can be climbed by an athlete with a power output of 331 W, how long does it take the athlete to climb the building’s 442 m height? Assume the athlete has a mass of 55 kg and that all of the power goes toward doing work against gravity.
3. A runner exerts a force of 334 N against the ground while using 2100 W of power. How long does it take the runner to run a distance of 50.0 m?
4. A ship’s diesel engine has a power output of 13.0 MW. How much work is done by this engine in 15.0 min?

5. One horsepower (1 hp) is the unit of power based on the work that a horse can do in one second. This is defined, in English units, as a force of 550 lb that can move an object 1 foot in 1 s. In SI, 1 hp equals 745.7 W, or 745.7 J of work delivered in 1 s. Suppose you have a horse that delivers 745.7 W of power, but that it does the work in only 0.55 s. How much work has this horse done?
6. The 300-series Shinkansen train of Japan has aluminum cars, so that it can reach high speeds more easily. Ten of the sixteen cars of a 300-series train have their own 300.0 kW motors, one for each of their four axles. What is the work done by one car's four motors during 25 s?
7. When it is completed in 2002, the International Financial Center in Taipei, Taiwan, will be the tallest building in the world. The International Financial Center will also have the fastest elevators in the world. Two of the 63 elevators will travel from the ground floor to the eightyninth floor in just 39 s. Suppose the power output of each elevator motor is 158 kW. How much work will these motors do in lifting the elevator to the eighty-ninth floor?
8. The space shuttle, which was first launched on April 12, 1981, is the world's first reusable space vehicle. The shuttle is placed in orbit by three engines that do 1.4×10^{13} J of work in 8.5 min. What is the power output of these engines?
9. Borax was mined in Death Valley, California, during the nineteenth century. It was transported from the valley by massive wagons, each pulled by a team of mules. Suppose the team does 2.82×10^{7} J of work on the wagon for 30.0 min? How much power is delivered, on the average, by the team? Express your answer in both watts and horsepower (1 hp =745.7 W).
10. James Watt did not invent the steam engine, but by adding a condenser to an existing engine he discovered how to make steam engines more efficient and practical. His own engine of 1778 was able to do 3.0×10^{6} J of work in 5.0 min. How much power was delivered by this engine?