#17 Work, Energy and Power Post-class

Due: 11:00am on Monday, October 1, 2012

Note: You will receive no credit for late submissions. To learn more, read your instructor's Grading Policy

Exercise 6.44

The total consumption of electrical energy in the United States is about 1.0×10^{19} joules per year.

Part A

What is the average rate of electrical energy consumption in watts?

Express your answer using two significant figures.

ANSWER:

P = 3.2×10^{11} W

Correct

Part B

If the population of the United States is 300 million, what is the average rate of electrical energy consumption per person?

Express your answer using two significant figures.

ANSWER:

P = 1.1 $\mathrm{kW/person}$

Correct

Part C

The sun transfers energy to the earth by radiation at a rate of approximately 1.0 kW per square meter of surface. If this energy could be collected and converted to electrical energy with 40 $\%$ efficiency, how great an area (in square kilometers) would be required to collect the electrical energy used by the United States?

Express your answer using two significant figures.

ANSWER:

S = 790 $\mathrm{km^2}$

Correct

Exercise 6.39

At a waterpark, sleds with riders are sent along a slippery, horizontal surface by the release of a large, compressed spring. The spring with a force constant k = 4300$\mathrm{N/m}$ and negligible mass rests on the frictionless horizontal surface. One end is in contact with a stationary wall. A sled and rider with total mass 69.0kg are pushed against the other end, compressing the spring 0.375m . The sled is then released with zero initial velocity.

Part A

What is the sled's speed when the spring returns to its uncompressed length?

ANSWER:

v = 2.96 $\mathrm{m/s}$

Correct

Part B

What is the sled's speed when the spring is still compressed 0.225m ?

ANSWER:

v = 2.37 $\mathrm{m/s}$

Correct

Exercise 6.52

The aircraft carrier *John F. Kennedy* has mass $7.4 \times 10^7 \mathrm{kg}$. When its engines are developing their full power of 280000 hp, the *John F. Kennedy* travels at its top speed of 35 knots $(65 \mathrm{km/h})$.

Part A

If 70% of the power output of the engines is applied to pushing the ship through the water, what is the magnitude of the force of water resistance that opposes the carrier's motion at this speed?

Express your answer using two significant figures.

ANSWER:

F = 8.1×10^6 N

Correct

± Baby Bounce with a Hooke

One of the pioneers of modern science, Sir Robert Hooke (1635-1703), studied the elastic properties of springs and formulated the law that bears his name. Hooke found the relationship among the force a spring exerts, $\vec{F}$, the distance from equilibrium the end of the spring is displaced, $\vec{x}$, and a number k called the *spring constant* (or, sometimes, the *force constant* of the spring). According to Hooke, the force of the spring is directly proportional to its displacement from equilibrium, or

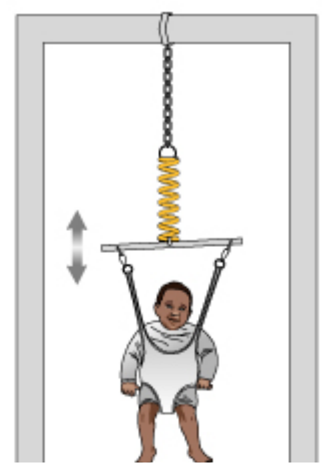
$$\vec{F} = -k\vec{x}.$$

In its scalar form, this equation is simply

$$F = -kx.$$

The negative sign indicates that the force that the spring exerts and its displacement have opposite directions. The value of k depends on the geometry and the material of the spring; it can be easily determined experimentally using this scalar equation.

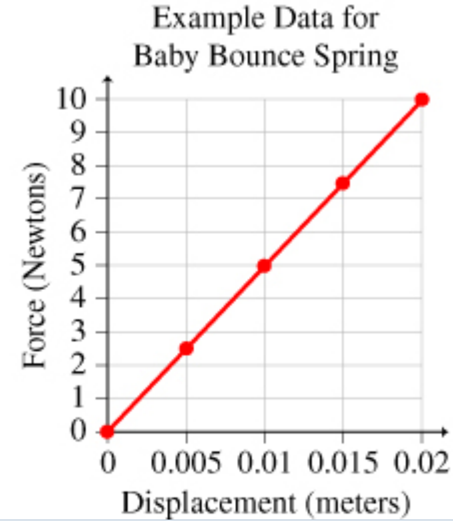
Toy makers have always been interested in springs for the entertainment value of the motion they produce. One well-known application is a baby bouncer, which consists of a harness seat for a toddler, attached to a spring. The entire contraption hooks onto the top of a doorway. The idea is for the baby to hang in the seat with his or her feet just touching the ground so that a good push up will get the baby bouncing, providing potentially hours of entertainment.



Part A

The following chart and accompanying graph depict an experiment to determine the spring constant for a baby bouncer.

Displacement from equilibrium, x (m)	Force exerted on the spring, F (N)
0	0
0.005	2.5
0.010	5.0
0.015	7.5
0.020	10



What is the spring constant k of the spring being tested for the baby bouncer?

Express your answer to two significant figures in newtons per meter.

Hint 1. How to approach the problem

Look at the pattern in the data to determine what number must multiply the distance to achieve the force exerted on the spring. Look at both the table and the graph.

Hint 2. Find the spring constant from the graph

The relationship between the displacement and force is linear. This set of data follows the form of $y = mx + b$, where m is the slope of the line and b is the *y* intercept. For all springs, the force is 0 when the displacement is 0 so $b = 0$. This leaves the slope of the line to determine the relationship between displacement and force. What is the slope that you get from the graph?

Express your answer as a fraction in unsimplified form.

Hint 1. Slope equation

Slope is given by the change in y divided by the change in x. In this case, $m = \Delta F/\Delta x$.

ANSWER:

k = 500 $\mathrm{N/m}$

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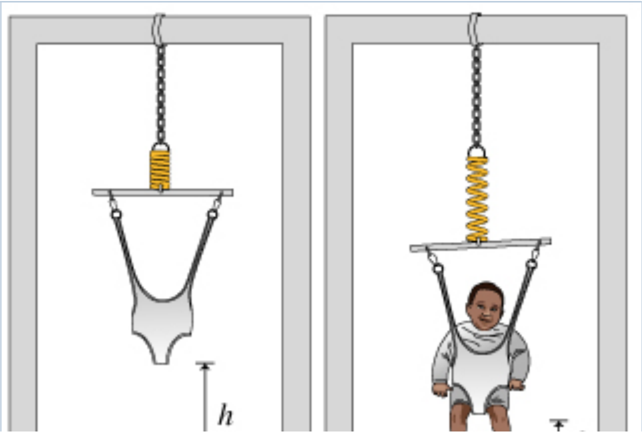
k = 500 $\mathrm{N/m}$

Correct

Part B

One of the greatest difficulties with setting up the baby bouncer is determining the right height above the floor so that the child can push off and bounce. Knowledge of physics can be really helpful here.
If the spring constant $k = 5.0 \times 10^2\ \mathrm{N/m}$, the baby has a mass $m = 11\ \mathrm{kg}$, and the baby's legs reach a distance $d = 0.15\ \mathrm{m}$ from the bouncer, what should be the height h of the "empty" bouncer above the floor?

Express your answer in meters to two significant figures.



Hint 1. How to approach the problem

Use Hooke's law to determine the displacement x of the spring from equilibrium given the force the spring must exert to hold up the baby. The displacement must lower the baby toward the floor until the baby's feet can touch.

Hint 2. Which force to use

The force the spring exerts is equal in magnitude but opposite in direction to the force exerted on it by the weight w of the baby.

Hint 3. Find the force exerted by the baby

The weight of the baby is equal to the force exerted on the spring. What is the weight of the baby?

Express your answer in newtons to three significant figures.

Hint 1. Formula for weight

Recall that the weight of an object is given by

$$w = mg,$$

where m is the mass of the object and g is the acceleration due to gravity.

ANSWER:

w = 108 N

Hint 4. Find the displacement of the spring

Use Hooke's law to determine how far the spring would stretch downward once the baby is placed in the seat. How far does the bottom end of the spring move?

Express your answer in meters to two significant figures.

ANSWER:

x = -0.22 m

ANSWER:

h = 0.37 m

Correct

A displacement of $-0.22\ \mathrm{m}$ for the spring holding up a baby may not seem very large but you must consider how small babies are. Also, once the baby begins jumping up and down, the extra energy allows the spring to stretch further than 0.22 m and a resonant frequency may be achieved. At resonance the bouncing may become too violent, leading to a potentially dangerous situation for the little bouncer.

Score Summary:

Your score on this assignment is 101.4%.
You received 40.55 out of a possible total of 40 points.