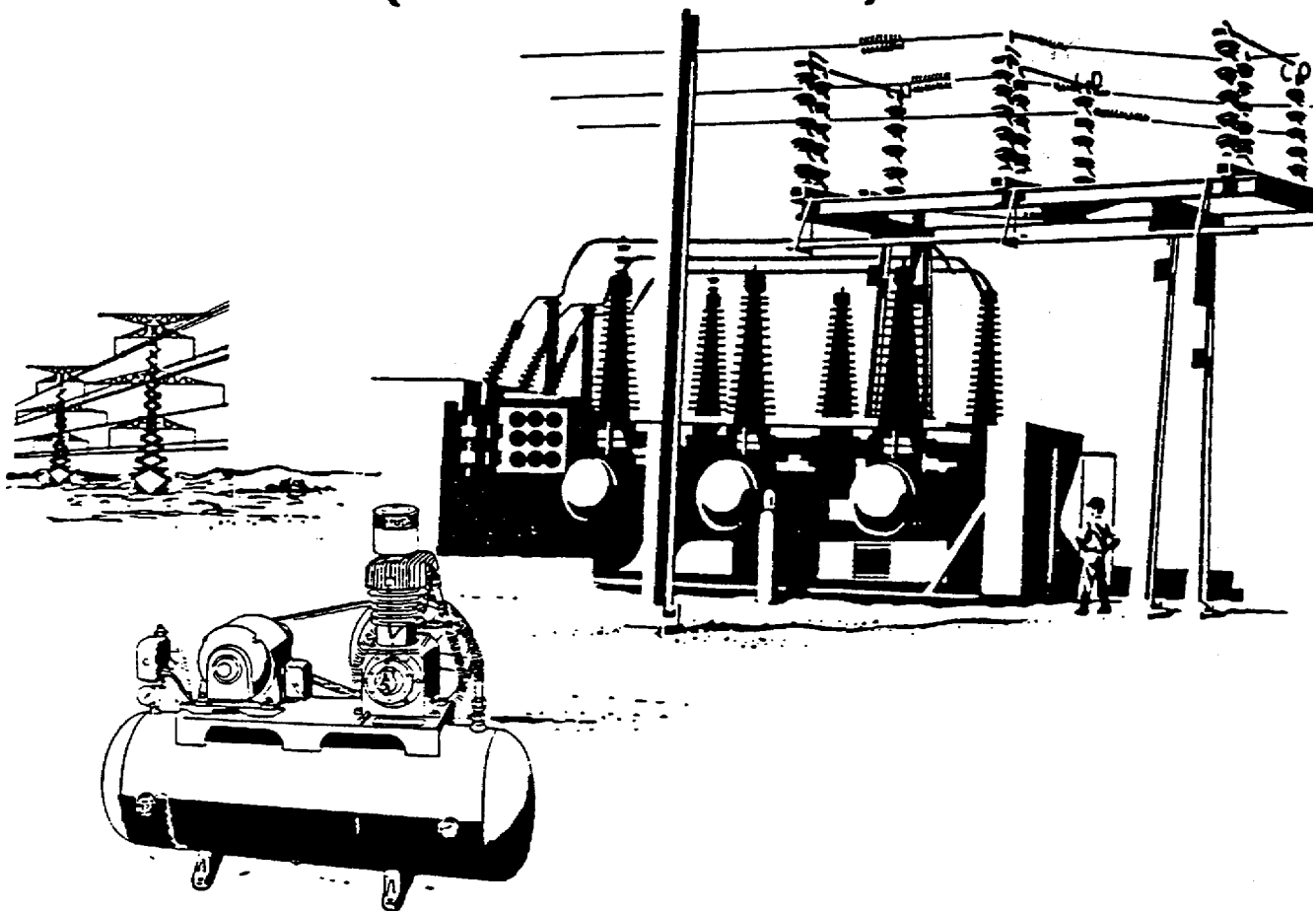


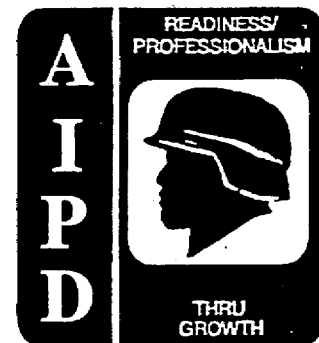
SUBCOURSE
IT0348

EDITION
A

US ARMY INTELLIGENCE CENTER
WORK, POWER, AND ENERGY
(ELECTRICAL)



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM



WORK, POWER, AND ENERGY (ELECTRICAL)

Subcourse Number IT 0348

EDITION A

US ARMY INTELLIGENCE CENTER
FORT HUACHUCA, AZ 85613-6000

2 Credit Hours

Edition Date: December 1996

SUBCOURSE OVERVIEW

This subcourse is designed to teach you to perform work, power and energy calculations for electrical circuits.

This subcourse replaces SA 0732. Prerequisites for this subcourse are subcourses IT 0332 through IT 0335. If you are taking this subcourse for review purposes, you may not need the prerequisite subcourses.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will be able to perform each of the following objectives:

- Convert watts to horsepower.
- Convert horsepower to watts.
- Calculate watts in electrical circuits.
- Calculate horsepower in electrical circuits.
- Calculate the efficiency of electrical circuits and motors.

CONDITION: Given electrical circuits and necessary values for voltage, current, resistance, and power.

STANDARD: To demonstrate competency of this task, you must achieve a minimum of 70% on the subcourse examination.

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LESSON
WORK, POWER, AND ENERGY (ELECTRICAL)
OVERVIEW

LESSON DESCRIPTION:

Upon completion of this lesson, you will know how to convert watts to horsepower and horsepower to watts, and calculate horsepower, watts, and efficiency of electrical circuits.

This lesson replaces SA 0732.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will be able to perform each of the following objectives:

- Convert watts to horsepower.
- Convert horsepower to watts.
- Calculate watts in electrical circuits.
- Calculate horsepower in electrical circuits.
- Calculate the efficiency of electrical circuits and motors.

CONDITION: Given electrical circuits and necessary values for voltage, current, resistance, and power.

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1A

Whenever an electric current flows through a resistance, heat is generated. Heat is a form of energy and, since energy cannot be created, the heat must be produced by a conversion of energy from the electric energy to the form of heat energy.

The soldering iron with which you will be working converts electrical energy to heat energy. In this case, we use the heat energy to do work. The lights in this room convert electrical energy to light energy.

In our study of mechanical work, power, and energy, we learned that power is the time rate of doing work or consuming energy.

The formula for solving the amount of power used is:

$$\text{Power} = \frac{\text{work}}{\text{time}} \quad \text{frame } \underline{3A}$$

$$\text{Power} = \text{work} \times \text{time}. \quad \text{frame } \underline{5B}$$

1B

YOUR ANSWER: The watt, then, is the time rate for doing electrical work. Yes, this is true. But this answer is not the most correct answer.

Return to frame 3A and select the answer that tells a more complete story than this one does.

2A

YOUR ANSWER: Watt.

Quite right.

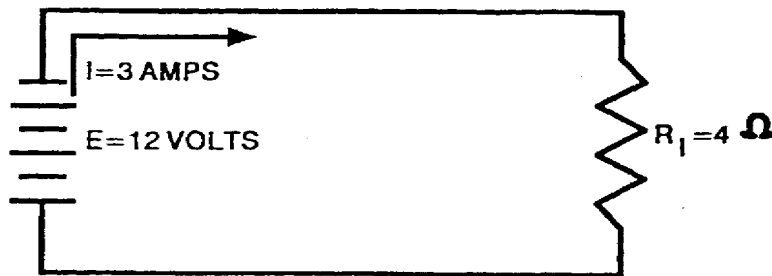
When we say that 746 watts equal one horsepower, we mean that the power consumed by an electrical device may be expressed in equivalent horsepower.

For example: Consider the power consumed by a large motor that draws 125 amperes from a 600-volt circuit.

$$P = E \times I = 600 \times 125 = 75,000 \text{ watts.}$$

This may be expressed in equivalent horsepower as

$$\frac{75,000 \text{ watts}}{746 \text{ (watts in 1 hp)}} = 100.2 \text{ hp}$$



How much power is consumed in the circuit above?

36 watts. frame 4A

12 watts. frame 6B

3A

YOUR ANSWER: Power = $\frac{\text{work}}{\text{time}}$.

Right.

The unit of measurement for electrical power is the WATT. One watt: of power equals the work done in one second by one volt of potential difference in moving one coulomb of charge. Since one coulomb per second is an ampere, power in watts equals the product of amperes times volts. Thus:

Power in watts = volts x amperes

or

$$P = E \times I.$$

Where P is power in watts, E is voltage and I is the intensity of current flow.

The watt then is:

the time rate for doing electrical work. frame 1B

the time rate for consuming electrical energy. frame 6A

both the above. frame 5A

3B

YOUR ANSWER: 100 watts.

Our response. How come?

You have already solved a similar problem, using the formula $P = E \times I$, or you couldn't have gotten to the preceding page. Once more, $P = E \times I$, NOT $P = IR$.

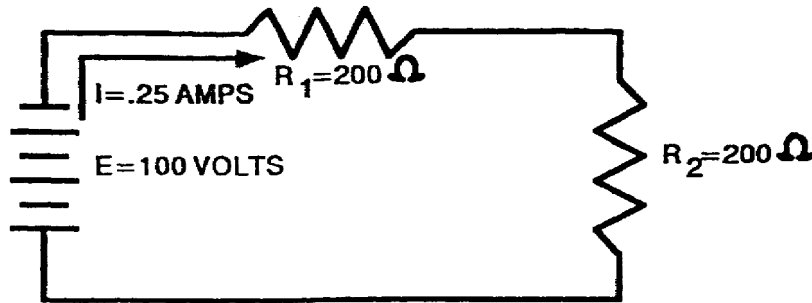
With the formula $P = E \times I$ firmly in your mind, return to frame 4A and solve for the correct answer.

4A

YOUR ANSWER: 36 watts.

Very good. $P = E \times I$.

Let's try another one.



How much power is consumed in the circuit?

25 watts. frame 7A

1 00 watts. frame 3B

4B

YOUR ANSWER: $P = \frac{E^2}{R}$.

R

Right you are.

$P = E \times I$. $P = I^2 R$ and $P = \frac{E^2}{R}$

R

Now, solve this problem.

A certain circuit consumes 600 watts of power from a 200-volt source.

What is the current flow in the circuit?

3 amperes. frame 8B

120,000 amperes. frame 10A

5A

YOUR ANSWER: Both the above.

Very good.

Electrical power is the time rate at which charge is forced to move by voltage. This is why the power in watts is equal to the product of volts and amperes. Thus, the basic power formula is $P = E \times I$.

For example, when a 6-volt battery produces 2 amps, in a circuit, the battery is producing 12 watts of power.

The voltage states the amount of work per unit of charge, and the current includes the time rate at which the charge is moved.

There is a further example of the relationship between electrical power and mechanical power in the fact that

746 watts = 1 horsepower = 550 ft.-lbs. per second.

746 watts = 1 horsepower = 33,000 ft.-lbs. per minute.

The unit of measurement for the amount of power consumed in a circuit is the

watt. frame 2A

volt. frame 8A

5B

YOUR ANSWER: Power = work x time.

Come, come now.

Power is the time rate for doing work or consuming energy.

When we talk about the rate of something, we are going to divide that "something" by time. For example: If you drove 200 miles in 5 hours, you would have to divide 200 by 5 to find out how many miles-per-hour you were traveling. there are many other such "rates," such as miles-per-gallon, gallons-per-minute, or, in our case, salary-per-month. These are all "rates," some quantity per unit of time.

Return now to frame 1A and select the correct answer.

6A

YOUR ANSWER: The watt, then, is the time rate for consuming electrical energy.

You are correct, as far as you have gone. But you seem to have forgotten one very important point. Before energy can be consumed, work must be done.

Now, go back to frame 3A and select the more correct answer.

6B

YOUR ANSWER: 12 watts

No.

The formula for power is $P = E \times I$, NOT $P = I \times R$.

Once more, electrical power is the time rate at which charge is forced to move by voltage. This is why the power in watts is equal to the product of volts and amperes. The basic power formula is $P = E \times I$.

Let's return to frame 2A and solve for the correct answer.

6C

YOUR ANSWER: 100 watts.

Wrong.

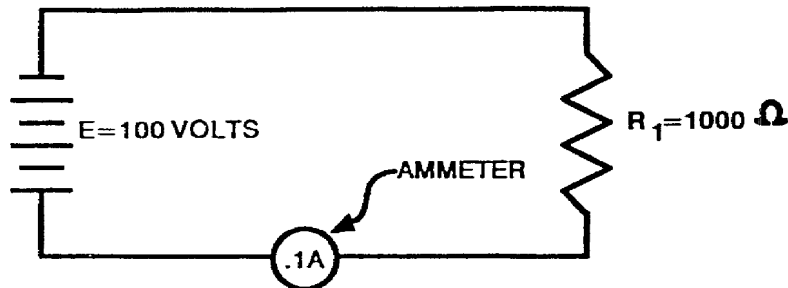
With the formula written right on the problem page, you still won't use it. Come on now, let's get down to the business at hand. $P = E \times I$, not $P = IR$. Get this formula straight in your mind; you will be using it for a long time to come.

Now, let's go back to frame 7A and solve the problem correctly.

7A

YOUR ANSWER: 25 watts.

Right. P is still equal to $E \times I$.



What is the power consumption in the circuit?

10 watts. frame 9A

100 watts. frame 6C

7B

YOUR ANSWER: $P = E \times I$.

Well, at least you remembered the basic power formula.

But you were asked, which formula you would use to solve for power, if voltage and resistance of the circuit were known.

We just gave you the formula on the preceding page: $P = \frac{E^2}{R}$

R

Here is an explanation as to how we arrive at this formula. $P = E \times I$ in our basic power formula. $I = \frac{E}{R}$ in Ohm's law. We can substitute $\frac{E}{R}$ for " I " in the basic power

R

R

law; thus, $P = \frac{E \times E}{R}$ or $P = \frac{E^2}{R}$.

R

R

Now, go back to frame 9A and select the correct answer.

8A

YOUR ANSWER: Volt.

You are not correct.

Earlier in your studies of basic electricity, you were told that the "volt" is a unit of electromotive force. Now suppose you pushed against the bulkhead over there, surely you are applying a pressure; but unless you moved that bulkhead, you could not do work; thus, no work, no time rate for doing work. The same is true of that wall plug there in the bulkhead. We know that there is approximately 110 volts available there, 110 volts of electromotive force ready and able to do electrical work; but unless we use this voltage to make current flow, no electrical work can be done; thus, no power can be consumed.

Return to frame 5A and select the correct answer.

8B

YOUR ANSWER: 3 amperes.

Very good. Just a little transposition of our basic power formula, $P = E \times I$.

$$I = \frac{P}{E} \text{ and } E = \frac{P}{I}$$

$$P = E \times I.$$

$$P = I^2 R$$

$$P = \frac{E^2}{R}$$

A certain soldering iron offers 200 ohms of resistance to 3 amperes of current flow.

The power used, then, is $P = I^2 R = 3 \times 3 \times 200 = 9 \times 200 = 1800$ watts.

How much power is consumed by a circuit that has .5 ampere of current flowing through a resistance of 500 ohms?

125 watts frame 11A

250 watts frame 13A

9A

YOUR ANSWER: 10 watts.

Good. You are remembering that $P = E \times I$ in our basic power formula. When current flows in a resistance, heat is produced. The heat energy is evidence that power is used in producing current in a resistance. The power is generated by the source of applied voltage and consumed in the resistance in the form of heat.

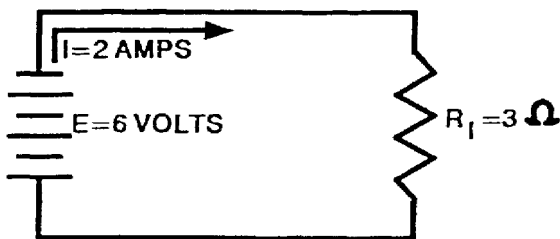
It is convenient, then, to have a power formula to express power in watts in terms of resistance.

For current:

$$P = I^2 R.$$

For voltage:

$$P = \frac{E^2}{R}.$$



R

$$P = E \times I = 6 \times 2 = 12 \text{ watts.}$$

$$P = I^2 R = 4 \times 3 = 12 \text{ watts.}$$

$$P = \frac{E^2}{R} = \frac{36}{3} = 12 \text{ watts.}$$

R 3

If you knew the voltage and resistance in a circuit, which formula would you use to solve for power?

$$P = \frac{E^2}{R} \quad \text{frame 4B}$$

R

$$P = E \times I \quad \text{frame 7B}$$

9B

YOUR ANSWER: 750 watts.

Again, we answer your answer with, not quite.

The formula again is $P = I^2 R$, not $P = IR$; you forgot to square I in your solution.

Go back to frame 11A and try again.

10A

YOUR ANSWER: 120,000 amperes.

Holy mackerel there. What size conductor do you suppose we would have to have to carry this amount of current?

This is just a little transposition of our basic power formula. We were given a power consumption of 600 watts from a 200-volt source and asked to solve for current (I). O.K., let's see how it's done.

- a. Correct formula: $P = E \times I$.
- b. $600 = 200 \times I$.
- c. Divide both sides by 200 thus,

$\frac{600}{200} = \frac{200}{200} \times I$. The 200's on the right side cancel each other,

$\frac{600}{200} = I$

and we have $I = \frac{600}{200} = ?$

$I = 3$

Return to frame 4B and try again.

10B

YOUR ANSWER: $E = I \times R$.

Oh! come on, now. All through this lesson, we have been dealing directly with the basic power formula. And when we ask you to identify the power formula, you give us $E = IR$, which is a variation of Ohm's law.

Let's get serious about this business and pay attention to what you are reading.

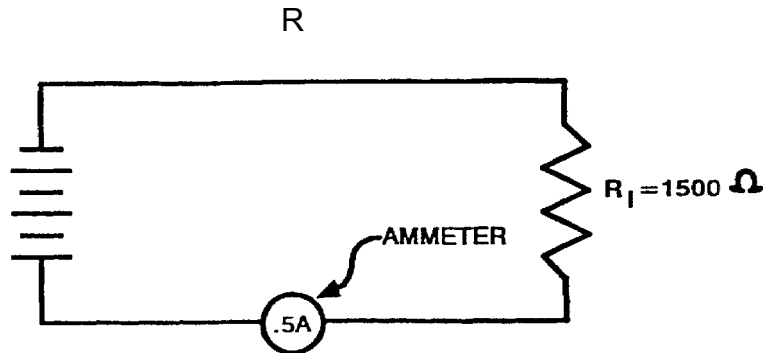
Return to frame 16A and select the correct answer.

11A

YOUR ANSWER: 125 watts.

Right.

Remember, $P = E \times I$; $P = I^2 R$; $P = \frac{E^2}{R}$.



How much power is consumed in the above circuit?

375 watts frame 14A

750 watts. frame 9B

11B

YOUR ANSWER: Both the above.

Very good.

We said earlier that 746 watts was equal to one horsepower. Now, let's solve a problem using equivalent horsepower.

In a certain circuit, we have a voltage source of 373 volts supplying 4 amperes of current. How much power is consumed by the circuit in (a) watts and (b) horsepower.

(a) 1492 watts. frame 17A

(b) 2 horsepower.

(a) 93.25 watts. frame 12B

(b) .11 horsepower

12A

YOUR ANSWER: (A) $P = 50,000$ watts. (b) $P = 1,000,000$ watts.

Wrong. But let's see why you are wrong.

First, you did not use the correct formula. With voltage and resistance known, we use the formula $P = \frac{E^2}{R}$, not $P = \frac{E}{R}$, which you used in both problems.

Problem (A)	$P = \frac{E^2}{R}$
	$P = \frac{5 \times 50}{1000}$
	$P = \frac{2500}{1000}$
	$P = ?$
	$P = \frac{E^2}{R}$
Problem (B)	$P = \frac{E^2}{R}$
	$P = \frac{100 \times 100}{10,000}$
	$P = \frac{10,000}{10,000}$
	$P =$

Complete these problems; then continue on to frame 16A.

12B

YOUR ANSWER: (a) 93.25 watts. (b) .11 horsepower.

You are not correct.

First of all, $P = E \times I$, not $P = \frac{E}{I}$

You have solved for horsepower correctly; however, let's try again.

a. $P = E \times I$

b. $P = 373 \times 4 = ?$ watts

c. $HP = ? \frac{\text{watts}}{746 \text{ (watts/hp)}} = \text{_____ hp.}$

After solving this problem correctly, continue on to frame 17A.

13A

YOUR ANSWER: 250 watts.

Not quite.

Again, the values given here, current flow at .5 ampere through a resistance of 500 ohms.

Let's see how we solve this problem.

- a. Use the correct formula: $P = I^2R$.
- b. $P = .5 \times .5 \times 500$
- c. $P = .25 \times 500$
- d. $P = ?$

We arrive at the formula $P = I^2R$ by using a variation of Ohm's law. $P = E \times I$ in our basic power formula. $E = IR$ in the variation of Ohm's law. Substituting IR for E in our power formula, we get $P = IR \times I$ or $P = I^2R$.

Return to frame 8B and solve for the correct answer.

13B

YOUR ANSWER: Ohms.

True. But you seem to be forgetting that heat is generated when current flows through a resistance. Heat being energy, it must have been created in this case by the conversion of electrical energy to heat energy. How much heat the resistor can consume before it will char or crack depends a lot on its physical size, especially with the carbon resistor; the larger it is, the more heat it can absorb and give up. So not only do we have to know the ohmic value, but we must also know how much current and voltage it will handle, since $P = E \times I$.

With this in mind, return to frame 18A.

14A

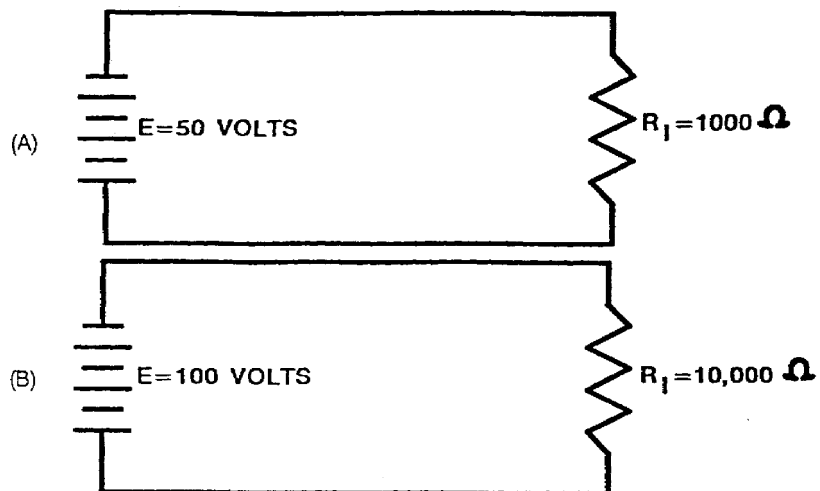
YOUR ANSWER: 375 watts.

Very good. $P = E \times I$.

$P = I^2 R$.

$$P = \frac{E^2}{R}$$

Solve for P in the following circuits:



(A) $P = 2.5$ watts.

frame 16A

(B) $P = 1$ watt

(A) $P = 50,000$ watts.

frame 12A

(B) $P = 1,000,000$ watts.

15A

YOUR ANSWER: Watts.

You are partially correct. But you seem to forget the unit of measurement for all opposition to current flow.

Resistors are devices which offer a specified amount of opposition to current flow.

Don't forget that resistors are rated not only in watts, but also in their ohmic value.

Return on to frame 18A.

15B

YOUR ANSWER: 128.7 percent

You have erred in two ways.

First, you were told that no machine is ever 100 percent efficient.

Second, you didn't pay any attention to the formula for efficiency.

Once more, the formula for efficiency:

Efficiency = $\frac{\text{output}}{\text{input}} \times 100$.

input

Now, let's solve the problem. We have a 1-hp motor which requires 960 watts input power:

a. Efficiency = $\frac{\text{output}}{\text{input}} \times 100$.

input

b. Put in known values. Efficiency = $\frac{746 \text{ (watts/hp)}}{960 \text{ (input)}}$

960 (input)

Efficiency = _____ percent.

After solving this problem correctly, continue on to frame 20A.

16A

YOUR ANSWER: (A) $P = 2.5$ watts.

(B) $P = 1$ watt.

Right you are.

Electrical lamps and soldering irons are examples of electrical devices that are rated in watts. The wattage rating of a device indicates the rate at which the device converts electrical energy (power) into another form of energy, such as light and heat.

For example, a 100-watt lamp will produce a brighter light than a 75-watt lamp, because it converts more electrical energy into light energy.

Electric soldering irons are of various wattage ratings, with the high wattage irons changing more electrical energy to heat energy than those of low wattage ratings.

Rather than indicate a device's ability to do work, its wattage rating may indicate the device's operating limit. These power limits generally are given as the maximum or minimum safe voltages and currents to which a device may be subjected. However, in cases where a device is not limited to any specific operating voltage, its limits are given directly in watts.

The basic power formula is:

$$P = E \times I. \quad \text{frame } \underline{18A}$$

$$P = I \times R. \quad \text{frame } \underline{10B}$$

17A

YOUR ANSWER: (a) 1492 watts.

(b) 2 horsepower.

You are correct.

Remember always to use the formula provided, and you can't go wrong.

Let's review our study of electrical power.

1. The unit of measurement for power consumed in a circuit is the

_____.

ANSWERS

1. watt	2. The basic power formula is $P = \text{_____} \times \text{_____}$.
2. $P = E \times I$	3. $P = E \times I$ is the basic formula for _____.
3. power	4. With current and resistance known in a circuit, power consumption can be found by using the formula $P = \text{_____}$.
4. $P = I^2 R$	5. With voltage and resistance known in a circuit, power consumption can be found by using the formula $P = \text{_____}$.
5. $P = E^2 \div R$	6. One horsepower is equal to _____ watts.
6. 746	7. 746 watts is equal to one _____.
7. horsepower	8. Power is the _____ rate for consuming energy.
8. time	9. Power is the product of voltage and _____, and its unit of measurement is the _____.
9. current, watt	10. The power formula can be written in several separate forms. Underline the form in which it cannot be written. a. $P = EI$ b. $P = \underline{E^2}$ c. $P = IR$ d. $P = I^2 R$ R
10. $P = IR$	

Continue on to frame 19A.

18A

YOUR ANSWER: $P = E \times I$.

This is correct. $P = E \times I$.

A resistor is an example of a device whose limit is given directly in watts. It may be used in circuits with widely different voltages, depending on the desired current. However, the resistor has a maximum current limitation for each voltage applied to it. The product of the resistor's voltage and current must not exceed a certain wattage.

Thus, resistors are rated in watts, in addition to their ohmic resistance value. Resistors of the same resistance value are available in different wattage values. Carbon resistors, for example, are commonly made in wattage ratings of 1/3, 1/2, 1, and 2 watts. The larger the physical size of a carbon resistor, the higher its wattage rating, since a larger amount of material will absorb and give up heat more easily.

Resistors are rated in

watts. frame 15A

ohms. frame 13B

both the above. frame 11B

18B

Here are the correct answers.

a. 67.8 percent

b. 3300 watts.

c. 4.42 horsepower.

If your answers do not agree, turn to frame 23A for correct solution.

If your answers do agree, turn to frame 25A and continue.

19A

We have one more item to learn before we come to the end of this lesson. That item is efficiency.

All machines lose some power by heat and friction. If they didn't, they would be 100 percent efficient and the output would be equal to the input. For instance, suppose a one-horsepower motor only required 746 watts to operate at its rated horsepower. We know that one horsepower is equal to 746 watts, so the output would equal the input and the motor would be 100 percent efficient.

To find out just how efficient an electrical device is, we use this formula.

$$\text{Efficiency} = \frac{\text{output (watts)}}{\text{input (watts)}} \times 100.$$

Let us suppose we have a 10-horsepower motor connected to a 400-volt source at 20 amps. The output then is 10 x 746 (watts in one hp) or 7460 watts. The input is $P = E \times I = 400 \times 20 = 8,000$ watts. Now, let's see how efficient this motor is.

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100 = \frac{7460}{8000} = .9325 \times 100 = 93.25 \text{ percent},$$

or rounded off 93.3 percent.

Now you try one.

What is the efficiency of a 1-horsepower motor that requires an input of 960 watts?

77.7 percent. frame 20A

128.7 percent. frame 15B

20A

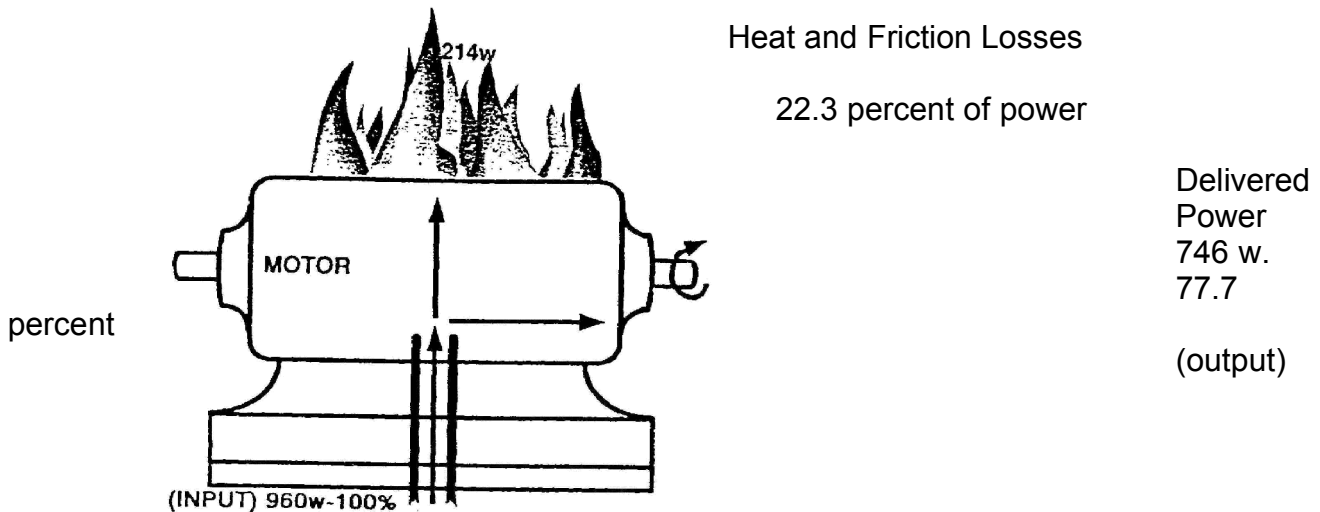
YOUR ANSWER: 77.7 percent

Correct. We had an input of 960 watts and an output of one horsepower. We were told that one horsepower is equal to 746 watts; our problem looks like this:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100 = \frac{746}{960} \times 100 = 77.7 \text{ percent}$$

$$960 \times 100 = .777 \times 100 = 77.7 \text{ percent}$$

The balance of power, 22.3 percent, is lost as heat or friction.



In the figure above are pictured the power and the power losses. If you follow the arrows through this picture, you will find the input power is electrical power. It splits up in the motor, going in two directions. The losses in the form of heat are radiated upward, and the output in the form of mechanical power is delivered to the shaft.

Now consider this problem. We have a 5-horsepower motor that draws 20 amperes from a 200-volt circuit; what is the efficiency of this motor?

93.25 percent.

frame 22A

107.23 percent

frame 24A

21A

YOUR ANSWER: 373 watts.

Wrong. But do not despair; we will go over the problem with you.

The problem again was to solve for the input power of a 4-hp motor operating at 80 percent efficiency.

- a. Use the correct formula: Efficiency = $\frac{\text{output}}{\text{input}} \times 100$.
- b. Substitute known values $80 = 4 \times \frac{746 (\text{watts/hp} \times 100)}{\text{input}}$.

- c. Multiply both sides by "input"; thus,

$$80 \times \text{input} = \frac{4 \times 746 \times 100}{\text{input}} \times \text{input}.$$

- d. "Input" on right side cancels out, and we have

$$80 \times \text{input} = 4 \times 746 \times 100.$$

- e. Divide both sides by 80:

$$\frac{80 \times \text{input}}{80} = \frac{4 \times 746 \times 100}{80}; \text{ thus,}$$

$$\text{input} = \frac{4 \times 746 \times 100}{80} = \underline{\hspace{2cm}} \text{ watts.}$$

Complete the problem, then continue on to frame 26A.

22A

YOUR ANSWER: 93.25 percent.

You are correct.

Now, let's see how we could solve for the input power, if the efficiency and output were known.

First, we will use the correct formula:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100.$$

Now, suppose that we had a 5-horsepower motor operating at 74.6 per cent efficiency.

a. Put into formula known values:

$$74.6 = \frac{5 \times 746 \times 100}{\text{input}}$$

b. Multiply both sides of the equation by "input":

$$\text{Input} \times 74.6 = \frac{5 \times 746 \times 100}{\text{input}} \times \text{input}$$

c. Then, we have

$$\text{input} \times 74.6 = 3730 \times 100 = 373,000$$

$$\text{input} = \frac{373,000}{74.6} = 5,000 \text{ watts.}$$

Now, you solve one.

A 4-horsepower motor operates at 80 percent efficiency; what is the input power?

3730 watts. frame 26A

373 watts. frame 21A

23A

This is how the problem should have been solved to obtain the correct answer:

- a. Efficiency = $\frac{\text{output (watts)}}{\text{input (watts)}} \times 100$.
- b. Output = 3(hp) x 746 (watts/hp) = 2238 watts.
- c. Input power = E x I = 220 x 15 = 3300 watts.
- d. Efficiency = $\frac{2238}{3300} \times 100 = .678 \times 100 = 37.8$ percent.
- e. To solve for equivalent horsepower, simply divide the input power (in watts) by 746 (watts per hp).

Thus:

$$\frac{3300}{746} = 4.42 \text{ hp.}$$

Now, continue on to frame 25A.

24A

YOUR ANSWER: 107.23 percent.

We can't very well go along with your answer, since we already have told you that NOL machine is ever 100 percent efficient.

Our problem is to solve for the efficiency of a 4-hp. motor drawing 20 amperes from a 200-volt circuit. O.K., let's solve it.

- a. $P = E \times I$.
- b. $P = 200 \times 20 = 4,000$ watts.
- c. Efficiency = $\frac{\text{output}}{\text{input}} \times 100$.
- d. Efficiency = $\frac{5 \times 746 \text{ (watt, hp)}}{4,000 \text{ watts}} \times 100$.
- e. Efficiency = _____ percent.

After you solve this problem correctly, continue on to frame 22A.

25A

1. In our study of electrical power, we found that the unit of measurement for electrical power is the _____.

ANSWERS

1. watt	2. The time rate for consuming energy is _____.
2. power	3. The basic power formula is $P = \text{_____} \times \text{_____}$.
3. $P = E \times I$	4. If current and power in a circuit were known, you could solve for voltage by using the formula $E = \text{_____}$.
4. $E = \frac{P}{I}$	5. In a circuit where voltage and power are known, you could solve for voltage by using the formula $I = \text{_____}$.
5. $I = \frac{P}{E}$	6. We have two formulas with which to express power in watts in terms of resistance; they are: for current, $P = \text{_____}$. for voltage, $P = \text{_____}$.
6. current, $P = I^2 R$ voltage, $P = \frac{E^2}{R}$	7. Write the three formulas for power. $P = \text{_____}$ $P = \text{_____}$ $P = \text{_____}$
7. $P = E \times I$ $P = I^2 R$ $P = \frac{E^2}{R}$	8. The ratio of power output to power input is called _____.
8. efficiency	9. Efficiency is the ratio of power _____ . to power _____.
9. output input	Now, if you feel you are ready, continue on to the examination.

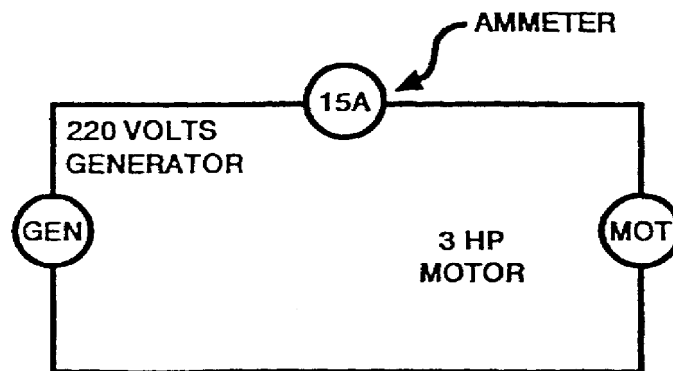
26A

YOUR ANSWER: 3730 watts.

Very good.

Just don't forget to use the correct formula. The correct formula will depend on the known factors. By knowing the basic formula, substituting in the known values, a little transposing, and you are in business.

Let's solve another problem.



- a. What is the efficiency of the 3-hp motor in the above drawing? _____percent.
- b. What is the input power in watts? _____watts.
- c. What is the input power in equivalent horsepower? _____hp.

Turn to frame 18B for correct answer.