ELECTRICITY AND THE HUMAN BODY

Body Resistance

18. Different parts of the human body have different resistances.

DRY BODY SKIN RESISTANCE	100,000 – 600,000 OHMS
RESISTANCE OF INTERNAL ORGANS (SUCH AS HEART, LUNGS, LIVER, ETC.)	100 – 600 OHMS

Dry body skin has a (higher / lower) resistance to the flow of the electric current than the internal organs of the body.

19. Electricity may have difficulty getting past the resistance of dry body skin.

But, once electricity enters the body, it will flow (more easily / with more difficulty) through internal organs, such as the heart, lungs and nerve centers.

20. Skin resistance is much higher than the resistance of internal organs. So, (skin resistance / the resistance of internal organs) determines the amount of electricity that can enter the body.

21. Look at the skin on your hand. The skin is thicker (on the back of your hand / at the palm of your hand near the thumb).

22. The thickness of body skin helps determine its resistance.

At points on the body where the skin is thicker, the body offers (more / less) resistance to electric current.

23. Just as different points on an individual's body have different resistances, you would expect that dry body skin resistance (is about the same / varies) from one person to another.

24. Notice that we have talked about the resistance of *dry* body skin. Suppose a person's skin is wet.

Since water is a good conductor of electricity, it will cause skin resistance to be (lower / higher).

25. Perspiring or standing on wet ground will reduce the resistance of body skin.

Performing maintenance on any electrical equipment during a rainstorm or when standing on wet ground is (a safe / an unsafe) practice.

26. **Ma** is the abbreviation for milliampere. The word "milli" means one-thousandth.

    A milliampere is _____-_____ of an ampere.

27. One-thousandth of an ampere can be expressed as 1 milliampere, or as (.100 / .010 / .001) ampere.

28. Ten milliamperes is expressed by which of these? *(Circle your answer.)*

    10.0 ampere

    .010 ampere

    1.001 ampere

Refer now to Exhibit 1.

29. Exhibit 1 outlines the physical effects of electricity on the body. The values on the chart are given in milliamperes.

    The values shown on the chart are approximations that will (vary from person to person / be the same for all individuals).

30. As shown on the Exhibit 1 chart, most people begin to feel the effects of an electric shock at _____ ma.

31. Suppose that a person touches a live electrical conductor that carries 110 volts, and that the person's body offers 100,000 ohms of resistance. You can use Ohm's Law to figure out the amperage that will flow through the person's body.

$$I = \frac{E}{R}$$

I = Amperage
E = Voltage
R = Resistance

Supply the correct values for E and R from the information given above.

I = _____

32. Now divide voltage by resistance.

100,000 ⟌ 110.000

The result is about _____ amperes.

EXHIBIT 1

PHYSICAL EFFECTS OF ELECTRIC CURRENT ON THE HUMAN BODY

CURRENT IN MILLIAMPERES	EFFECT
0.4 ma	SLIGHT SENSATION ON THE HAND
1.1 ma	THRESHOLD OF SHOCK PERCEPTION
1.0–8.0 ma	SHOCK–NOT PAINFUL–MUSCLE CONTROL NOT LOST
8.0–15.0 ma	INCREASINGLY HAZARDOUS AND UNCOMFORTABLE SHOCK–THIS RANGE COULD CAUSE CARDIAC ARREST IN SOME INDIVIDUALS IF THE SHOCK LASTS LONG ENOUGH
16.0 ma	SHOCK–VERY PAINFUL–USUALLY THE LET-GO THRESHOLD–PROBABILITY OF CARDIAC ARREST INCREASES SHARPLY FROM THIS POINT UPWARD
16.1–20.0 ma	PAINFUL SHOCK–VICTIM CANNOT LET GO OF ENERGIZED OBJECT–MUSCLE CONTROL LOST
20.0–50.0 ma	SHOCK–PAINFUL AND SEVERE MUSCLE CONTRACTION–BREATHING VERY DIFFICULT
50.0 ma–100.0 ma	HEART AND NERVE DAMAGE–SEVERE BURNS–CONSIDERABLE POSSIBILITY OF DEATH
100.0 ma and upward	PROBABLE DEATH–IN MOST INDIVIDUALS, INSTANT DEATH WILL RESULT FROM CONTACT WITH THIS AMOUNT OF CURRENT

33. This amount of amperage, .001, is one - thousandth of an ampere. It can be expressed as (1 ma / 10 ma / 100 ma).

34. Now suppose that a person's body skin resistance has decreased to 10,000 ohms because the person's skin is wet. The person comes into contact with a 110-volt circuit.

$$I = \frac{E}{R}$$

Supply the correct values for E and R from the information given in this frame and write in the values below.

$$I = \_\_\_\_\_$$

35. Now, divide voltage by resistance.

Suppose a person touches a 110-volt circuit, and has a body resistance of 10,000 ohms. The amount of amperage that would flow through the person's body is _____ amperes.

36. This amount of amperage, .011, is the same as (1 ma / 11 ma / 110 ma / .1 ma).

Refer again to Exhibit 1.

37. Eleven milliamperes would give the person (a slight tingling sensation / an extremely uncomfortable shock).

38. Now assume that the circuit contains 220 volts instead of 110 volts. Again, the person's body resistance is only 10,000 ohms because his skin is wet. Fill in the values for the formula:

$$I = \frac{E}{R} \qquad I = \_\_\_\_\_$$

39. Divide volts by resistance.

If a person with a body skin resistance of 10,000 ohms comes into contact with a 220 - volt circuit, _____ amperes will flow into the person's body.

40. This is the same as _____ milliamperes.

Refer again to Exhibit 1.

41. If 22 milliamperes enter a person's body, the chances are good that (the person will feel uncomfortable for five or ten minutes following the shock / severe injury or death will result from the shock).

42. Under some circumstances, if a person comes into contact with a 110- or 220-volt circuit, the person will get only a mild electric shock. But under other circumstances, contact with 110 or 220 volts can produce severe injury or death.

The difference in the effect of electrical contact depends on how much _____ the person's body offers.

43. And, how much resistance a person's body offers (always remains the same under any conditions / varies according to several conditions, such as whether the skin is wet or dry).

44. Usually, a person (can / cannot) figure out in advance how accidental electrical contact will affect him.

45. This is why thousands of people are injured or electrocuted each year by household current, which is 110 or 220 volts.

Because a circuit is called a household current circuit (means / does not mean) that it is safe for you to touch.

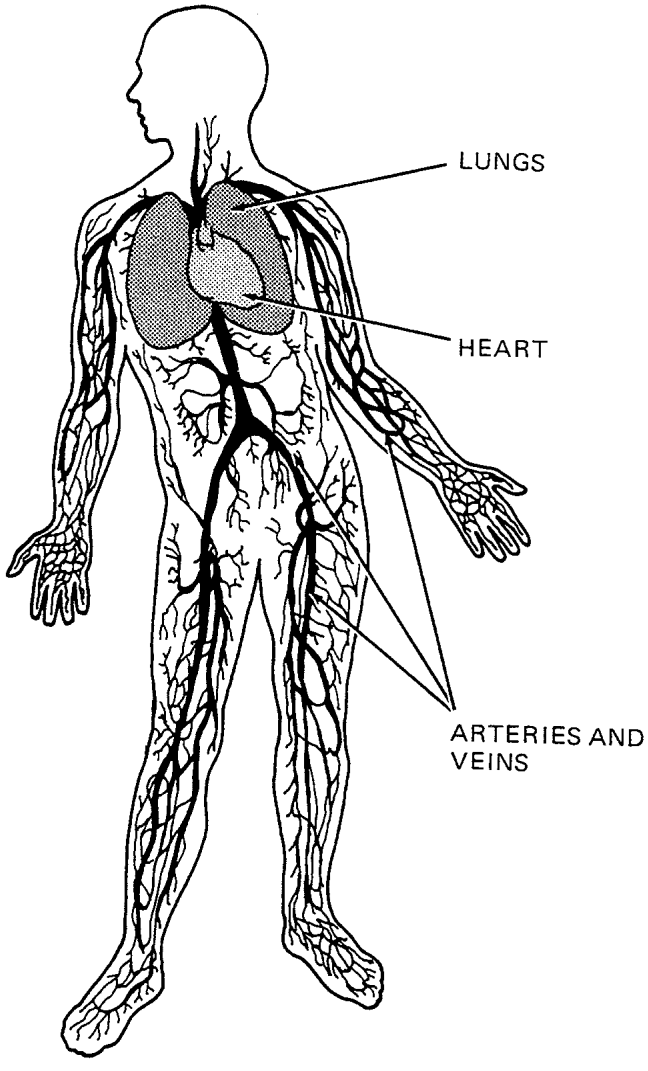
46. Most oil leases use 220 volts, 440 volts, 762 or 796 volts for powering lease equipment such as pump motors.

The potential for electric shock on an oil lease is (much less than / even greater than) in the home.

47. And, the chances that any electric shock will result in severe injury are _____.

The Cardiovascular System

48. This drawing represents the **cardiovascular** system.



The cardiovascular system consists of the _____, the _____, and the _____ and _____, also called blood vessels.

49. The heart, the lungs and the blood vessels are muscles.

Like other muscles in the body, they contract and relax according to the signals they receive from the _____.

50. Most muscles in the body are **voluntary** muscles. In other words, voluntary muscles usually move only when you *consciously* tell them to.

The muscles in your hand (are / are not) an example of voluntary muscles.

51. **Involuntary** muscles are those muscles that the body controls *automatically*. The heart, the lungs, and the walls of the blood vessels are involuntary muscles.

    Heart contraction and relaxation, breathing and blood circulation take place (with / without) conscious effort on your part.

52. Electricity causes both voluntary and involuntary muscles to *contract*.

    This is why an electric shock often makes it impossible for a person to (hold onto / let go of) the object that is causing the shock.

53. The body uses electricity to control the functions of the heart, lungs and blood vessels.

    By sending **electrical impulses** to the heart, lungs and blood vessels, the body causes these organs to _____ and then relax on a regular schedule.

54. This contraction and relaxation causes air to enter and leave the _____, and causes blood to be pumped through the body by the _____.

55. The part of the body that controls the activity of the heart, the lungs and the blood vessels is called the **autonomic nervous system**. Autonomic means automatic.

    Electrical impulses are sent out to the heart, lungs and circulatory system from the _____ _____ _____.

56. The heart, the lungs, and the blood vessels are called the (circulatory system / cardiovascular system / respiratory system).

57. The functions of the cardiovascular system are controlled by electrical impulses that come from the _____ _____ system.

The Effects of Shock

58. Suppose a person's body receives an electric shock. The person has accidentally touched a live electrical conductor.

    The muscles in the person's hand will _____ around the conductor.

Refer again to Exhibit 1.

59. If the amount of amperage entering the person's body is more than _____ ma, the person will probably not be able to let go of the conductor.

60. A powerful electric shock (can / cannot) prevent the body from controlling its muscles.

61. Imagine what happens if an electric shock passes through the heart muscle.

    Like a signal from the autonomic nervous system, the electric shock will tell the heart muscle to _____.

62. If the electric shock is great enough, it will cause the heart muscle to quiver in uncontrolled contractions. This quivering is called **ventricular fibrillation.**

    During ventricular fibrillation, the heart tries unsuccessfully to _____ while electric shock forces the heart muscle to _____.

63. The electrical impulses from the nervous system will try to get the heart back on schedule.

    But, if the amount of electric current applied to the heart from outside the body is _____ than the electrical impulses from the nervous system, the heart will continue to quiver.

64. If the heart muscle quivers long enough, the heart finally _____.

65. When the heart fails, this is called **cardiac arrest.**

    A person who receives an electric shock that results in ventricular fibrillation will _____ due to _____ _____ if his heartbeat cannot be restarted.

66. It does not take a large amount of electricity to cause ventricular fibrillation.

    However, the amount of electricity required _____ from person to person.

67. Suppose two people come into contact with 20 ma of current. One person has a history of heart trouble. The other person is younger and has no heart problems.

    The chances that ventricular fibrillation will occur are greater for (the young person / the person with heart trouble).

68. Health is one factor determining how electrical contact affects a person. Another factor is time.

    Electric shock causes veins to _____, restricting the flow of _____ through the body.

69. The longer a person is in contact with electricity before being freed, the _____ the chance of body damage due to restricted circulation.

70. The effects of electric shock are unpredictable. The amount of current that causes ventricular fibrillation in one person (will have the same effect on anyone / may not cause it in another person).