ASVAB

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FOLLOW-ALONG MANUAL

ASVAB

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INTRODUCTION

Welcome to our study guide for the ASVAB. “ASVAB” stands for the Armed Services Vocational Aptitude Battery. The scores from this test are used to determine which positions you are eligible for in the military. The test is offered to students who are in at least the tenth grade. Adults can take the test as well. Here is some basic information about the test.

It consists of multiple choice questions. You don’t need to worry about essays or even short answer questions. Everything will be multiple choice. One of the nice things about a multiple-choice question is that the correct answer is right there in front of you. You don’t have to come up with it on your own; you just need to pick it out from a total of four options. Sometimes it can be easier to do this by finding the wrong answers than by finding the right answer. This can be a powerful strategy when you take a multiple-choice test. It is called the process of elimination because you are eliminating the wrong answers. Then, the only option left will be the correct answer. You can use this on any question when the answer is not obvious to you. All you have to do is to shift your focus from thinking, “What is the right answer?” to thinking, “What is the wrong answer?” If you can eliminate three wrong answers, then you have the right answer. But even if you can only eliminate one or two wrong answers, this still increases the chances that you will choose the correct answer. So, if you are not sure of the correct answer, you can start by eliminating the wrong answers.

You are allowed to take the ASVAB more than once if you want to. If you want to retake it, you have to wait at least one month. Then, if you want to retake it again, you need to wait at least six months. Depending on your situation and your plans, you may want to take the ASVAB right away so that you can get a sense of how well you will do on it. Then, you can study for a month and retake it. If you do this, you will gain a lot of familiarity with the test, and this can help you to use your study time more effectively because you will know exactly what to expect on the test. There won’t be any surprises. If you do this, pay careful attention to the questions that you are either uncertain about or that you are pretty sure that you got wrong because you can use

that information to focus your study time on the material that you really need to review in order to do your best the next time that you take the ASVAB.

The test has nine sections. About half of the test covers the kinds of things you learn in school, like math and science. The other half covers more technical skills, such as electronics and mechanics. In this guide, we will review content and strategy for each of the nine sections that will help you to do your best. It is natural for people to have stronger and weaker areas and so to do better on some sections of the test than they do on others. One of the purposes of the ASVAB is to help you and the military identify what kinds of jobs would be a good fit for you. On the Go Army website, there is a place where you can input your scores on the sections of the ASVAB and it will let you know which jobs you might qualify for. The formulas used to determine this are different for every job, and most positions require ASVAB scores to meet a certain requirement for only a few sections of the test. Let's look at an example of this to see how it works. Say that your goal was to aim for a skilled technical position in the Marines. For that position, they will look at four scores. These are the general science, verbal expression, mechanical comprehension, and mathematics knowledge. Verbal comprehension is the result of combining the scores that you earn on the word knowledge and paragraph comprehension sections of the ASVAB, while the other three scores are each their own section of the test. Your scores for those five sections of the test will be combined together and evaluated. This means that that position will not rely on your scores from the other sections. This may all sound kind of complicated, but here is what you should take away from it:

One. You do need a minimum score to enlist. This score depends on the branch of the service that you want to enter. It also depends on whether you have a high school diploma or a GED. In general, if you have a GED, you need to score higher than about half of the people who take the test. If you have a high school diploma, you need to score better than about a third of the people who take the test, although you need to do a bit better for the Army National Guard and Air National Guard.

Two. In addition, you need to earn a certain score to qualify for a particular occupational specialty. These scores generally involve three to five sections of the test combined into one

score—not your score on the entire test. So, if you have one or two weak areas, you do not need to worry about that too much—so long as that section isn't considered for an occupational specialty that you are interested in.

You have up to three hours to take the test. As you study each section of the guide, you will learn how many questions you will have and how long you have for that particular section. You will see that, for some sections, there are more questions than minutes, which means that you will have less than one minute to answer each question on average. Do not let this stress you out. In those cases, the questions are usually of the type that you can answer very quickly, sometimes in just a few seconds. In fact, most people do not need all of the required time. That said, there are time limits. You should practice pacing yourself so that you will know in advance if your pace of answering questions is too slow for you to complete that section in time. This is one reason why it might be a good idea to take an ASVAB test before you study so that you can be more familiar with the test.

You can take the ASVAB it at a Military Entrance Processing Station—where you take it on a computer-- or a Military Entrance Test site, where it is a written version. The test is slightly different depending on whether you take it at the former or latter location. In each section of the guide, we will go over the differences between the paper version and the computer version. If you have the option of where to take the test, you should choose whichever version you are more comfortable with taking. Some people prefer paper tests, and some people prefer computerized tests. If you don't have an option, don't worry: while the time you are given and the number of questions that you need to answer differs, the test is basically the same in both formats.

If you are taking the test on a computer, once you enter an answer, you can't change it. The computerized test is also adaptive. This means that if you get a question wrong, you will see an easier question. And if you get a question right, you will see a harder question. Now, don't spend time worrying about this—some people devote a lot of energy to thinking things like, "oh no, this is an easy question—that must mean I am doing a really bad job." But the problem is that your definition of an easy question might be different from the test's definition of an easy

question. Something might be easy to you because you happened to have a teacher who taught it very thoroughly and very well, but the test treats it as a hard question because many previous test takers didn't know the answer because their teachers didn't teach that topic adequately. So you should not spend any time worrying about this while you take the test. Just focus on getting the questions right. You just should know that the test is adaptive so that if you hear other people saying that the test was really hard or really easy—or if it seems hard or easy to you—you shouldn't pay too much attention to that. Just do your best on the test.

With the paper version, you can review and change answers for the section that you are working on. Also, on the paper version, there is no guessing penalty, so answer every question—even if you do not know the answer. Use the process of elimination that was described previously to rule out answers that you know are wrong and choose from the remaining possibilities. With the paper version, you can skip questions that you do not know the answer to and then return to them if you have time. This is a good strategy for the paper version of the test: if you can't identify the correct answer in a moment or two, move on, because it is a better use of your time to work on the other questions. Then, if you have time remaining at the end, you can go back to those difficult questions and see if you can approach it from a different perspective. Remember that this strategy is not an option if you are taking the test on a computer. Also, if you have extra time, you can go over your answer sheet to be sure that you have one and only one answer to each question on the test.

When you take the computerized test, you cannot return to a question once you have answered it. So, you will simply need to do your best and then move on.

Not only is the format different depending on whether you take the computerized or the paper test, but the content is also a bit different. We will go over the differences between the two versions as we prepare for each section of the test.

In general, the ASVAB is the same for all branches of the military. However, there is one special section for the Navy. This is called the coding speed section. We will briefly review that section here. Remember that you only need to take this section if you are interested in the Navy.

Here is how the coding speed section works: this section is testing your ability to quickly locate a number on a chart. This chart is called a key, and it will be included on the test. It will consist of a list of words with a number next to each word. The number will have four or five digits, so it will be a long number. The questions will include one of the words from the key, and the correct answer to the question will be the number that corresponds to that word in the key. If you imagine looking at the menu board in a fast food restaurant and then being asked how much a large fry costs, you have the idea behind the coding test because you will be asked to find the number associated with a word.

Your goal for this test is to find the correct number as quickly as you can. Here is how to do your best on this section: when you find the number in the key, repeat it to yourself over and over as you look for the same number among the answer choices. Think about this example: let's say that the question asks you for the number associated with the word "hamlet" in the chart. You will look at the chart and find the word "hamlet" as quickly as you can. Then, you will read the number associated with the word "hamlet" in the chart. Let's say that it is nine-three-seven-eight. Once you see that number, repeat "nine-three-seven-eight" to yourself as you scan the answer options to find the one that is nine-three-seven-eight.

If you struggle with reading information from a chart or a graph, you may want to do some extra preparation for this section. That can be in the form of studying tables that you find online and carefully getting data from them. You may find it helpful on the test to place your finger on or near the table in order to be sure that you are looking at the right piece of information.

Now, this is a speed test, so you will want to work as quickly as you can—but only as quickly as you can without making mistakes. You may want to practice a bit with some online tables to develop your skills or, as mentioned above, by taking an actual ASVAB if you have a month to wait before you take it again.

One strategy that you can use is to group the numbers you are trying to remember. Here is how to do that. Let's say that the number in the key is two eight five seven. Instead of trying to

remember two, eight, five, and seven, think of the number as twenty-eight fifty-seven. Most people will find it easier to remember twenty-eight fifty-seven than to remember two eight five seven.

Here's one other strategy that might help you. Know that in the answer choices, the numbers will always be listed in ascending order. That means that the smallest number will be option A and the largest number will be option D. This can help you find the correct answer choice more quickly since you know what order the answers are in.

If you have any issues with reversing numbers and letters—especially if you have been diagnosed with dyslexia—you may need to learn some special strategies for this section to compensate for that.

That's what you need to know for the coding speed test.

Now, let's go over some general advice for doing your best on tests. Here are a few things to remember.

First. You need to prepare by getting a good night's sleep and eating a good breakfast on the day of the test. Sleep and nutrition both affect your ability to think clearly. If possible, try to establish a good sleep schedule at least a week before the test. This is difficult for some people and in some situations, but sleeping well and eating well can help you think clearly and do your best. While you should definitely eat breakfast on the day that you take the test, a very large meal—especially one with a lot of fat—can leave some people feeling tired. Instead, try to eat something that has a good balance of fat and protein.

Second. Be sure to arrive a bit early for the test. This will help reduce your stress level and prevent problems.

Third. Dress in layers. You never know if the testing center will be warm or cold, and either one can be distracting.

Fourth. Don't try to cram the night before the test. This is usually not helpful, and, in fact, it can actually harm your performance. Instead, come up with a study plan that lets you study a little bit each day. This kind of studying has been shown to be more effective at helping you remember the material than studying for a long time for just a few days. Consider how much time you have before the exam and how long this guide is, and then come up with a plan to study some each day and spread out what you learn. Many people find it helpful to their memory if they share what they learned with someone else, so if there is a person who is willing to listen to you talk about what you have been learning, tell them. It will help you remember.

Fifth. Don't let yourself get stressed out because this can also hurt your performance. If you find yourself feeling stressed, take a few deep breaths and focus on your breathing. This can help you calm down so that you can focus on the test and do your best.

Sixth. Be sure to read the directions on the test very carefully. This is advice that you have probably heard about school work and tests for your entire life, but it is so important. If a question on the ASVAB has the word "not" in it, but you didn't notice that word, you are going to find it nearly impossible to answer that question correctly. At the very least, you will end up wasting a lot of time figuring out what happened and correcting your mistake. So, read everything slowly and carefully. Working quickly is of no help to you if it means that you make avoidable mistakes. So, remember: read slowly and carefully.

Seventh. Know that before you begin the test, you will have the chance to answer some practice questions and also to ask any questions that you might have to the person who is giving you the test. These practice questions are particularly important if you are taking the computerized version because they give you a chance to be sure that you are comfortable with how the computer itself works and how the software for the test works before you actually take the test. So be sure to take these practice questions seriously so that you can address any problems related to the computer before you are taking the actual test. Also, if you have any questions, be sure to ask the person who is giving you the test. There are no stupid questions in

a situation like that: it is much better to get an answer than to make avoidable mistakes on the test.

This concludes the introduction to this guide. Next, we will prepare for each of the nine sections of the test. We will begin with the general science section.

GENERAL SCIENCE (GS)

INTRODUCTION

This section of the ASVAB tests your knowledge of science topics from the main branches of science. This section of the guide will review the basic ideas that you need to know in order to do your best on the General Science section of the ASVAB.

If you take the ASVAB on a computer, you will have eight minutes to answer sixteen questions. If you take it on paper, you will have twenty minutes to answer forty-five questions. Either way, that is about two questions per minute, which means that you don't have a lot of time to think, so you will need to work quickly.

What kinds of topics are covered on the general science section? This section will have questions from the topics that are typically covered in high school level science classes in three areas: Earth and space science, life science, and physical science. Earth and space science covers geology, meteorology, and astronomy. Life science is usually called biology, and physical science covers chemistry and physics. Do not feel intimidated by that—especially the physics, which is a class that many people find very challenging. The ASVAB will usually cover only general and introductory topics in these areas of science. You do not need to know everything that is typically taught in a high school physics class to do well on this test.

Let's look at the sample questions on the official ASVAB website to give you a sense of the kinds of questions that you might see on this portion of the test.

The first question asks why it is that air is less dense than water. The correct answer to this question is that the molecules in a gas are farther apart than the molecules in a liquid. Again, remember that you do not have to come up with this answer yourself—you only need to determine that it is the best of the four answers provided to you in the multiple-choice options. The other options are that it is lighter, that the molecules are closer together, and that it moves more easily. There is an important bit of strategy that you can learn from this question. That strategy is to work with what you know and not to worry about what you do not know. Let's say that you read this question, but you had absolutely no idea what a molecule is. One answer

choice is that the molecules are farther apart, and another is that they are closer together. Even without knowing what molecules are, does it make sense that things packed closer together would make something lighter, or does it make more sense that things that have more space between them would be lighter? You should be able to recognize, just based on your real-world experience of lifting full and half-empty boxes, that things are lighter when there are fewer things in them. So, you should be able to eliminate the answer choice that the molecules are closer together even if you had no idea what a molecule is. This is a good example of using the knowledge that you have about the world to correctly answer a question, even in a situation where you are not familiar with all of the words or ideas in a question. Remember: don't get stressed out by the stuff that you don't know. Just build on what you do know.

The second question asks you to convert one hundred degrees Celsius to Fahrenheit. The correct answer is two hundred and twelve. You should know that this is not a random temperature, but the boiling point of water. This is another question where you can build from what you know even if you do not know everything that you think you should. For example, one of the answer choices is one hundred degrees Fahrenheit. But even if you don't know how to convert from Celsius to Fahrenheit, it doesn't make a lot of sense that the two temperatures would both be equal to one hundred degrees. Now, to get technical for a moment, there is one temperature that is the same in both Fahrenheit and in Celsius, but all of the other temperatures are different because they are different systems. And the odds are really in your favor that they won't pick the one temperature where they are the same. So even if you don't know anything about converting Fahrenheit to Celsius or what the common temperatures in both are, you could use logical thinking to determine that an answer that is one hundred degrees Celsius is extremely unlikely to be the correct answer to a question that asks for the equivalent of one hundred degrees Fahrenheit. So you can eliminate that answer. Now, let's say that you don't remember off the top of your head that one hundred degrees Celsius is the boiling point of water. Or maybe you remembered that part, but you didn't remember the boiling point of water in Fahrenheit. And you don't remember what the formula is for converting one to another. But maybe you do have a vague memory of a teacher or a textbook showing you that the formula for converting them has a fraction in it. If that's the case, then it's

really unlikely that another one of the answer options, which is two hundred, could be correct. After all, if you want to convert two hundred to one hundred, you just divide it by two. There is no need to use a fraction in the formula to get the correct answer. So your vague memory that the formula had a fraction in it should be enough to lead you to conclude that two hundred is very unlikely to be the correct answer. So, we've now been able to eliminate two of the answers, despite the fact that we don't really know what the correct answer is or how to find it. This might all sound a bit complicated, but the point is simple: if you don't know the correct answer to a question, you can usually use what you do know to eliminate one or more of the wrong answers.

The third question asks why salt helps to melt ice. The correct answer is that salt lowers the temperature at which water freezes. If you knew that, this is a pretty easy question to answer. But what can you do if you didn't know the answer? Again, work with what you do know in order to eliminate incorrect answers. For example, one of the incorrect answer choices is that the salt destroys the water molecules. But think about that for a minute: when ice melts, is the water destroyed? No, it is still water—it is just in its liquid form instead of its solid form. So that answer does not make any sense, and you can eliminate it. Another answer option is that the salt is attracted to the concrete below the ice. But think about that for a minute: does salt only work to melt ice when there is concrete below it? That doesn't make much sense. It also doesn't really explain how it would help melt ice if, for example, there were three feet of ice on the sidewalk: how would it be able to be attracted to concrete that was so far away from it and melt three feet of ice? And doesn't salt melt ice even if there is no other substance present? It does. So, even if you don't know why salt melts ice, you can be pretty sure that this answer makes no sense. You can eliminate it.

From these sample questions, you should be able to get a sense of the level of difficulty of the scientific concepts that will be tested on this section of the ASVAB. Also, you have now seen how the strategy of eliminating incorrect answer choices can be used when you do not know the answer to a question. After using that strategy, you can guess from the remaining choices.

As you can see, the test covers basic scientific concepts. This section of the guide will review the topics that are likely to appear on the test. Before we delve into topics specific to each area of science that will be covered, we will review two concepts that are relevant to all branches of science. These two concepts are the scientific method and measurement.

First, let's review the scientific method. There are different ways to gain information about the world. One of these ways is called the scientific method. Here are the six steps to the scientific method:

First. Make an observation. Scientists need to be curious and observant. For example, a scientist might notice that people who eat a lot of salad seem to be healthier. Noticing this would be making an observation about the world.

Second. Ask a question. Scientists will pose a question based on the observation, such as: Does eating more green vegetables reduce the risk of heart attacks? The question has to be something that you can observe and measure.

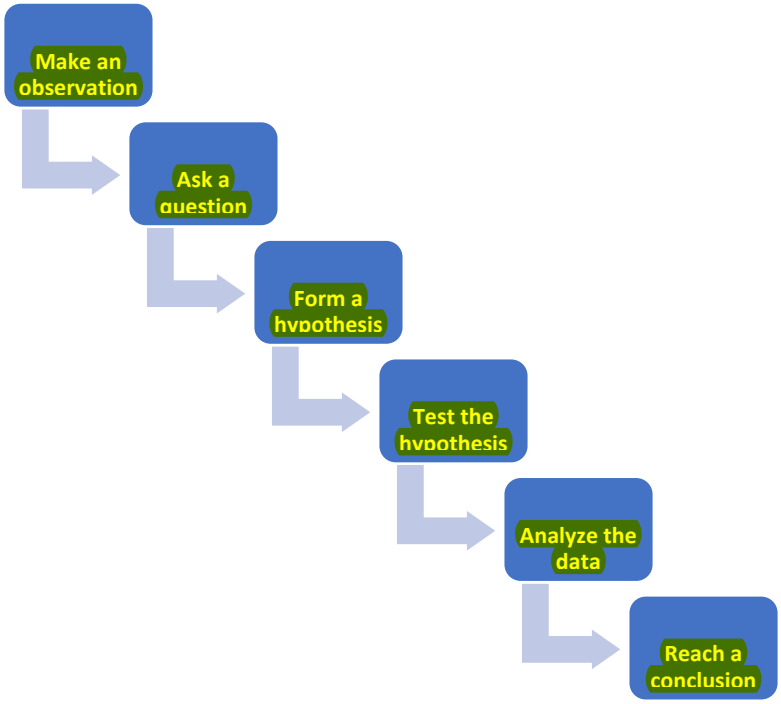
Third. Form a hypothesis. A hypothesis is an answer to the question. A hypothesis has to be something that you can test. For example, the statement "Angels do not exist" is not a hypothesis because you cannot test it. Continuing with our example, the hypothesis could be, "Eating three servings of green vegetables each day reduces the risk of heart attacks."

Fourth. Test the hypothesis. This test is an experiment. In this case, the scientist might give a survey to one thousand people and ask them questions such as, "On an average day, how many servings of green vegetables do you eat?" and "Have you ever had a heart attack?"

Fifth. Analyze the data. The next step is for the scientist to analyze the data. This means looking at all of the data to determine whether the hypothesis is accurate or not.

Sixth. Reach a conclusion. This is the final step of the process. The scientist will decide whether the experiment supports or does not support the hypothesis. Figure One summarizes the scientific method:

Figure One: The Scientific Method



Without even realizing it, you might use the scientific method in your daily life. For example, if you see a new kind of chili pepper in the grocery store, you have made an observation. If you wonder if it would be good in enchiladas, then you have asked a question. You may not be very formal about making a hypothesis, but you might conclude that the pepper would be great in enchiladas, so you would buy the ingredients and make the enchiladas. When you make them, you are testing the hypothesis, and when you eat them and discuss the flavor with your friends, you are analyzing the data. You will reach a conclusion about whether the chili pepper was or was not a good addition to the enchiladas.

There are some common problems that scientists run into when they use the scientific method. For example, let's say that, in our previous example of testing the relationship between eating vegetables and having heart attacks, our scientist only surveyed people in their twenties. Well, people generally do not have heart attacks until they are older, so if only younger people were surveyed, there would probably not be any relationship between their eating habits and heart

attack rates. If you surveyed people in their seventies, you might find different patterns in the data. The people or animals or objects that a scientist tests are called the sample. It is important that the sample be representative. This means that you can't test twenty-two-year-olds about how many heart attacks they have and then say that what you found is true for all people, because twenty-two-year-olds are not a good sample of the entire population when it comes to the question of having heart attacks. Scientists have to be sure that the sample is a representative sample. That means that it represents the population that they are testing.

But if scientists are careful when they design their experiments, they can use the scientific method in order to increase knowledge about a wide variety of topics. The amazing discoveries and inventions of the modern world all stem from the use of the scientific method.

Now, let's review measurement. There are two separate systems of measurement that you should be comfortable using. The first is called the standard system and the second is the metric system. If you are an American, you grew up with the standard system. Distances are measured in inches, feet, yards, and miles. There are twelve inches in a foot, three feet in a yard, and one thousand, seven hundred, and sixty yards in a mile. Volume is measured in cups, pints, quarts, and gallons. There are two cups in a pint, two pints in a quart, and four quarts in a gallon. Weight is measured in ounces, pounds, and tons. There are sixteen ounces in a pound and two thousand pounds in a ton. Figure Two summarizes the standard system:

Figure Two: The Standard System

Distance	**Volume**	**Weight**
12 inches = 1 foot	2 cups = 1 pint	16 ounces = 1 pound
3 feet = 1 yard	2 pints = 1 quart	2000 pounds = 1 ton
1760 yards = 1 mile	4 quarts = 1 gallon	

The metric system may be less familiar to you, but it is simpler to understand. The metric system uses the meter as the basic unit for measuring length. A meter is a little more than three feet long. The metric system uses grams as the basic unit for measuring mass. A paper clip weighs about one gram. Volume is measured in liters. You are probably familiar with two-liter soda bottles, so you already have a good idea of how much a liter is. The great thing about the metric system is that you can convert to larger and smaller amounts in multiples of ten, which makes it much easier to remember than the standard system. So if you want one thousand of something, you add "kilo" to the front of it. This means that one thousand grams is a kilogram, one thousand meters is a kilometer, and one thousand liters is a kiloliter. If you have just one one-hundredth of a unit, you add "centi" to the beginning of the unit. So one one-hundredth of a gram is a centigram, one one-hundredth of a liter is a centiliter, and one one-hundredth of a gram is a centigram. Figure Three summarizes the Metric system:

Figure Three: The Metric System

Name in words	Number	Prefix	Symbol
Millionth	.000001	Micro-	μ
Thousandth	.001	Milli-	m
Hundredth	.01	Centi-	c
Tenth	.1	Deci-	d
Unit	1	[no prefix]	
Ten	10	Deka-	Da
Hundred	100	Hecto-	h
Thousand	1000	Kilo-	k
Million	1,000,000	Mega-	M

In the standard system, temperature is measured on the Fahrenheit scale. In the metric system, the Celsius scale is used. You should know that water freezes at thirty-two degrees Fahrenheit and at zero degrees Celsius. Water boils at two hundred and twelve degrees Fahrenheit and at one hundred degrees Celsius.

This concludes the introduction to the general science section. We have reviewed the contents of the test, the scientific method, and two systems of measurement. Now, we will cover the basic concepts of Earth and space science that you should know.

Earth and Space Science

Let's begin with the Earth. There are four layers of the Earth. The outermost layer is called the crust. It is so thin relative to the size of the whole Earth that you could compare it to an apple skin. Beneath the crust is the mantle. The mantle can flow, but very slowly. Beneath the mantle is the outer core, which is liquid, and the inner core, which is solid.

Because the mantle moves, sections of the crust move on top of it. It is similar to chunks of ice floating on water in this way. This process of moving sections of crust is called plate tectonics. Plate tectonics is responsible for many of the phenomena that you see on the surface of the Earth. For example, when plates collide, the crust bunches together just like a blanket would if you pushed the edges together. This process forms mountains. When sections of the crust press against each other sideways, this causes earthquakes, which occur when built-up pressure from the colliding plates is released all at once.

Next, let's talk about rocks. Rocks belong to one of three groups based on how they are formed. When molten rock from deep inside the Earth cools and hardens, it forms igneous rocks. When lava flows out of a volcano, cools, and then forms a rock, it creates an igneous rock. Basalt and obsidian are examples of igneous rocks.

The second kind of rock is called sedimentary rock. These rocks form when small particles, such as sand, pebbles, shells, and other bits of material join together and harden into a rock. Shale and limestone are examples of sedimentary rocks.

The third kind of rock is called metamorphic rock, and it forms when intense heat and high pressure cause rock to form. Slate and marble are examples of metamorphic rocks.

You can think of rocks transitioning from one type to another through what is called the rock cycle. A rock would begin as an igneous rock after it, for example, cools from lava. Then, as a result of weathering and erosion, tiny bits of the rock would form into a sedimentary rock. If heat and pressure is applied to the sedimentary rock, it would result in a metamorphic rock. If

that metamorphic rock moves down from the Earth's crust so that it heats up and then becomes magma, it could form a new igneous rock and the cycle would begin again.

Next, we will consider what is above the surface of the Earth: the atmosphere. Without the atmosphere, there would be no life on Earth. First, the gasses of the atmosphere absorb and reflect some of the sun's rays, so they protect living things, which would be harmed by too much sunlight. And, these gasses in the atmosphere help to keep the Earth's temperature stable. Without them, the Earth would be too hot during the day—from too much sun light—but also too cold during the night. Because humans are adding carbon to the Earth's atmosphere, the temperature on Earth is getting higher. This process is called climate change.

The layers of the atmosphere are called, going in order from the Earth's surface outward, the troposphere, stratosphere, mesosphere, thermosphere, and exosphere.

The atmosphere is also necessary for the water cycle. Here is how the water cycle works: When it gets hot, water evaporates, which means that it changes from being a liquid on the Earth's surface to being a gas in the atmosphere. Then, as it cools, it condenses—which means that it moves back into a liquid state. It forms clouds. From there, it falls back to the surface of the Earth as precipitation, as either rain or snow. This water collects in rivers, lakes, and other bodies of water. When it evaporates, the cycle continues.

In the troposphere, when air moves, we call it wind. Because air is warmer near the ground, it rises. Then it encounters cooler air at higher elevations. This cool, heavy air sinks. This process creates convection currents, which transfer hear from one location to another. As the air moves, this is what creates wind.

Almost all weather happens in the lower portions of the atmosphere. We have already considered how rain, snow, and wind happen. Let's consider a few other weather events. A tornado is created in a thunderstorm that has high winds. A tornado is a swirling, funnel-shaped cloud. Because the winds are so high, a tornado can cause great damage. A hurricane is a very large storm that forms over warm ocean water. It also swirls, like a tornado, but it is much larger. Also, most tornados will only maintain their force for a few minutes, but a hurricane will

usually last for days and is much larger. When an area of high pressure stays in place over one area, for a long time, this causes a heat wave.

Next, we will review basic concepts in space science, which is also known as astronomy.

The center of our solar system is the sun. Remember that the sun is a star. It only looks different than other stars do because it is so much closer to us than other stars are. Stars have a life cycle, which takes an extremely long time compared to a human or animal life cycle. First, from a cloud of dust and gas, a star is formed. Because fusion occurs in a star, it is able to produce helium from hydrogen. A star that can do this is called a main sequence star. Once a star has used up its hydrogen, it becomes what is known as a blue giant. Then, it collapses and becomes a red giant. Then, depending on the size of the star, it becomes a white dwarf or a red supergiant. Red supergiants explode and become supernova. After a supernova, the remains form either a neutron star or a black hole.

The planets in the solar system are, in order from the sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. All of these planets orbit the sun, although they take different amounts of time to do so. There are four other kinds of objects in our solar system: asteroids, comets, meteors, and dwarf planets.

Returning to Earth, along coastlines, the water rises and falls two times per day. These are called tides. They are caused by the moon's gravity, which pulls the water toward the moon. This means that water on the side of the Earth that is facing the moon is at high tide. The moon is also responsible for eclipses. A solar eclipse occurs when the moon is right in between the sun and the Earth, which means that it will be dark on a certain portion of the Earth due to the shadow. A lunar eclipse occurs when the Earth is in between the sun and the moon. During a lunar eclipse, the moon appears to be a dark reddish color. The reason that it has this color is that the only sunlight reaching the surface of the moon has passed through the Earth's atmosphere, and the atmosphere filters out almost all of the blue light.

Seasons occur as a result of the tilt of the Earth in relation to the sun. This means that when it is winter in the northern hemisphere, it is summer in the southern hemisphere. It is summer when that portion of the Earth is tilted closer to the sun.

This concludes our discussion of Earth and space science.

LIFE SCIENCE

Next, we will review the basics of life science. You might be more familiar with the term "biology" to describe this branch of science.

We begin with cells. Cells are the basic unit of all living things. A very small living thing, such as bacteria, might only have one cell. A human being has trillions of cells. You usually need a microscope in order to see a cell. Unlike a one-celled bacterium, a human has different kinds of specialized cells, such as skin cells, nerve cells, and red blood cells. But all cells have the same four parts:

One. A membrane. This is the structure that surrounds the cell. It is like a skin for a cell in the sense that it forms the boundary between the cell and its environment.

Two. Cytoplasm. This term refers to all of the material inside of the cell membrane except for the nucleus of the cell.

Three. Ribosomes. Ribosomes are found in the cytoplasm; they make proteins.

Four. DNA. You can think of DNA as the instruction manual for a living thing. DNA stores information—genetic information. This information tells a cell what to do.

Some cells contain a nucleus, which is where most of the genetic information is located.

Cells can join together to form tissue. Tissue forms an organ, and organs form organ systems. Let's review the twelve systems of the human body:

The immune system includes your white blood cells, spleen, and bone marrow. Its job is to fight off diseases.

The urinary system includes the kidneys and bladder. It processes and then removes liquid waste from the body.

The skeletal system includes bones, cartilage, and ligaments. This system supports and protects the body.

The reproductive system, which differs in males and females, creates sex cells and sex hormones needed for reproduction.

The respiratory system includes the trachea, larynx, and lungs. This system moves and exchanges gases throughout the body.

The nervous system includes the nerves, spinal cord, and brain. It collects, moves, and interprets information.

The muscular system includes the muscles and tendons. It moves bones.

The integumentary system consists of the skin, hair, and nails. It protects the body and regulates temperature.

The endocrine system consists of glands; it produces chemicals called hormones.

The lymphatic system includes the lymph nodes and vessels. It moves lymph and defends against disease.

The cardiovascular system includes the heart, blood, and blood vessels. It moves oxygen, nutrients, hormones, and waste around the body.

The digestive system includes the esophagus, stomach, and intestines. It is responsible for digesting food.

An important life science concept to understand is the idea of homeostasis. The systems of the body are trying to maintain stability or balance, which is termed homeostasis. For example, your body wants to maintain a consistent temperature. If you are too cold, you will shiver, which will warm you up because your muscles are moving. If you are too hot, you will sweat, which will cool you down as the sweat evaporates. So both shivering and sweating are attempts by your body to maintain homeostasis. If homeostasis fails, you may get sick or even die.

Now let's briefly review some nutrition concepts. Humans need carbohydrates, proteins, and fat. A carbohydrate is a compound that stores energy; this category includes sugars. A protein is made of amino acids. Fats, which are also called lipids, store energy. Humans also need a variety of vitamins and minerals for optimal health.

Next, let's review some terms and concepts related to animals. In biology, living things are divided according to a classification system. The first level of classification is the kingdom, and there are six kingdoms. The two most familiar kingdoms are animals and plants, and the others are protists, fungi, monera, and archaea. Let's focus on the animal kingdom. The next level of classification under the level of kingdom is called a phylum, and there are over thirty phyla in the animal kingdom. One of these is called chordata, and it includes all of the creatures that have backbones. We call these vertebrates; animals without a backbone are called invertebrates. The level of classification under a phylum is called a class. Here are the main classes of chordates:

Amphibians. Most amphibians undergo metamorphosis during their life span, usually spending part of their life in water and part on land. They are cold-blooded, and they lay eggs without shells.

Reptiles. Reptiles are also cold-blooded, and they have scaly skin. They also lay eggs, which are shelled.

Birds. Birds are warm-blooded, and they have feathers, bony beaks, and no teeth. They lay eggs with hard shells.

Mammals. Mammals are warm-blooded. They have hair or fur, and the females produce milk to feed their young.

Fish. There are actually two different classes for fish, depending on their structure. Fish have gills instead of lungs and live in the water.

We can also divide animals according to what they eat: herbivores eat plants, carnivores eat other animals, and omnivores can eat plants and animals.

We use the term “ecosystem” to describe the environment in which an animal lives. A food chain or a food web describes how energy moves through an ecosystem. For example, imagine a plant growing. It gets its energy from the sun and, through photosynthesis, is able to turn the sun’s energy into glucose. We call the plant a producer because it produces its own energy. Now imagine that a grasshopper eats the plant. This is the first link in a food chain or a food web. We call the grasshopper a consumer because it is consuming energy produced by another source. Now a bird eats the grasshopper, forming the next link in the food chain. If a snake eats the bird, it becomes a link in the food chain. If an owl eats the snake, it is another link in the chain. Normally, herbivores are lower than carnivores on a food chain. What happens to the animal at the top of the food chain? When it dies, it will decompose, aided by organisms such as fungi and bacteria. They recycle organic matter, which can then be used as nutrients in the soil by the next generation of plants in that ecosystem.

We group similar ecosystems together and call those biomes. See Figure Four for a chart of the types of biomes:

Figure Four: Biomes

Tundra

- low temperature, short growing seasons

Desert

- little precipitation, little vegetation

Savanna

- woodland with widely-spaced trees

Chaparral

- shrubs and plants that tolerate drought

Grassland

- vegetation is mostly grasses

Tropical Forest

- hot, high humidity, lots of rain, lush vegetation

Temperate Forest

- wide temperature ranges, trees

Coniferous Forest

- cold, snowy winters, four distinct seasons, tall trees

Woodland

- low-density forest, shrubs and grasses

Marine

- all water environments

This concludes our discussion of life science; next we will review physical science topics.

Let's begin with the states of matter. There are four states of matter: solid, liquid, gas, and plasma. Think about this example: in the solid state, we call it ice. In its liquid state, we call it water. And, when it is a gas, we call it water vapor or steam. The key characteristic of a solid is that it has a fixed shape. Think of a cube of ice: as long as it stays frozen, its shape stays the same. On the other hand, a liquid conforms to the shape of whatever container it is placed in. If you pour liquid from a soda can into a glass, the liquid will fill the glass. But the volume of a liquid is fixed, which means that your soda doesn't expand when you pour it. It is going to stay in the glass; it isn't going to go floating around the room. On the other hand, a gas takes on both the volume and shape of its container. The fourth state of matter is called plasma. Plasma is much less commonly known, although it makes up most of the matter in the entire universe despite the fact that it is not common on Earth. Plasma is similar to a gas, but it also can respond to a magnetic field and it can conduct electricity. Whenever a substance changes state, we call this a physical change because the chemical makeup of the substance stays the same. On the other hand, when a substance undergoes a chemical change, this means that its elements combine or break down to form a new substance. When you cook an egg or burn wood, it undergoes a chemical change.

The basic building block of all substances is the atom. The atom is the smallest piece of an element that still has all of the properties of an element. Atoms are so small that trillions of them can fit in a period at the end of a sentence. Atoms consist of three main kinds of particles:

Neutrons have a neutral electrical charge.

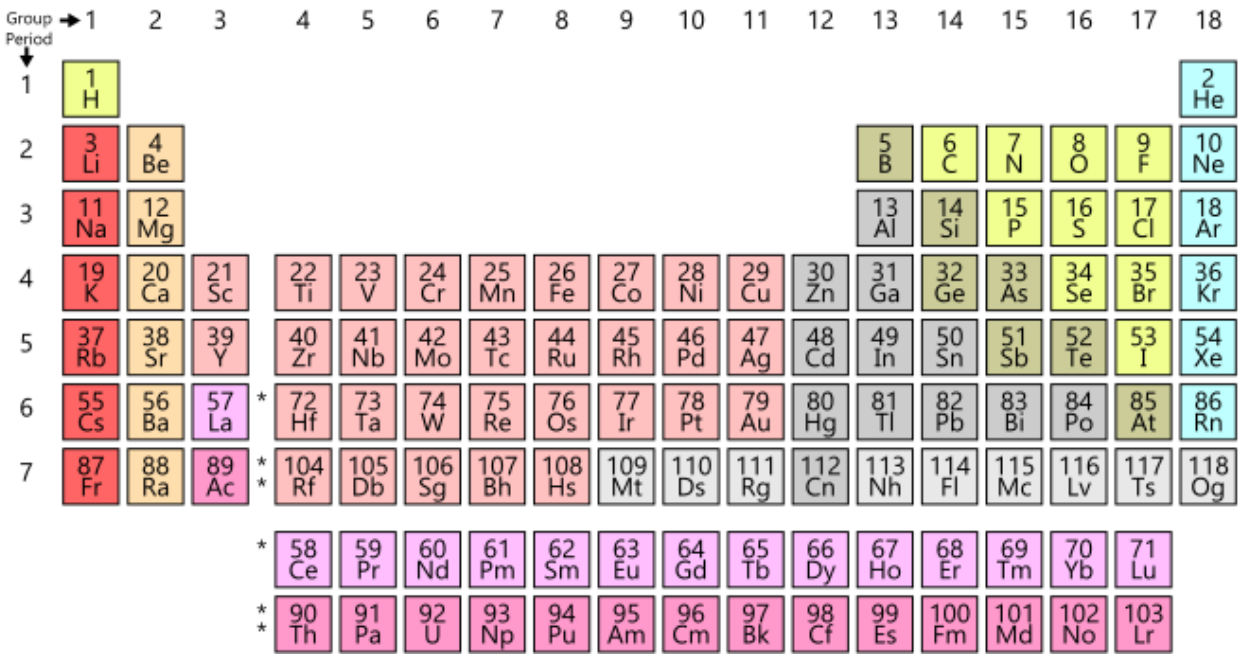
Electrons have a negative electrical charge.

Protons have a positive electrical charge.

The center of an atom is called the nucleus, and it is where the protons and neutrons are grouped together.

An element is a basic substance composed of atoms of that kind of element. We organize elements in the periodic table, which shows the relationships between the elements. See Figure Five, which is a periodic table:

Figure Five: The Periodic Table



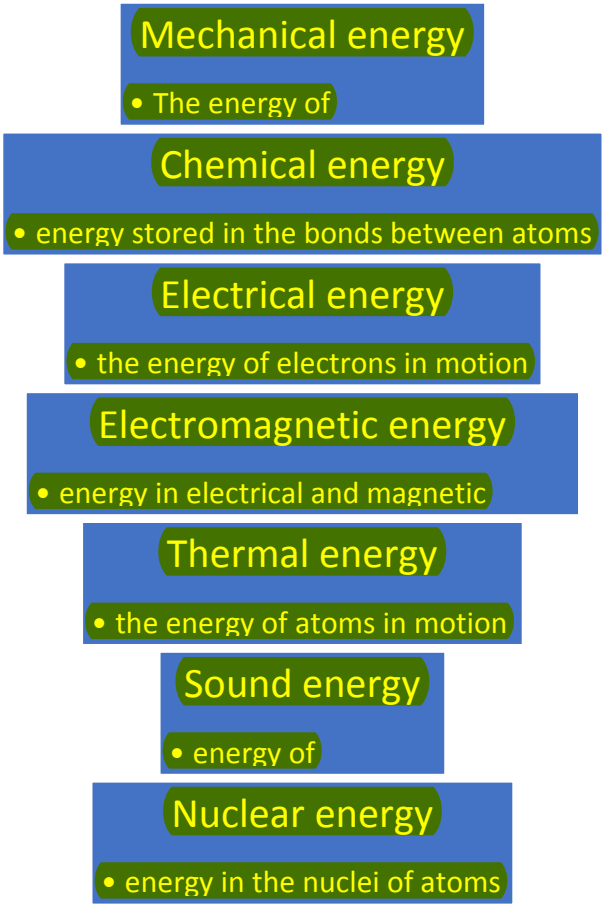
Source: Wikimedia Commons

In the periodic table, elements are arranged in a very specific way: by atomic number. The atomic number is the number of protons in each atom, which is different for each element. Each element has its own box on the periodic table. For example, the first box in the upper left-hand corner of the table has an "H" in it. This stands for hydrogen, which has one proton, and thus has a periodic number of one. If you look on the right side of the table, in the second row down, you will see the letters "N-E." This is the symbol for neon. It has the number ten above it because it has ten protons. The columns on the table are called groups. All of the elements that are in the same group have similar properties. Also, all elements are divided into three classes: metals, metalloids, and nonmetals. When we combine two or more elements together, this is called a compound.

In science, the word “work” has a different meaning than the way that we use that word in everyday conversation. In physics, work refers to the use of force to move an object. In physics, if you aren’t moving something, you aren’t doing work. We can use the equation work equals force times distance to describe what is happening. Similarly, the word “power” is used differently than it is normally used. In physics, power is a measurement of the amount of work that is done in a specific amount of time. We use the equation power equals work divided by time to represent this. At this point, you shouldn’t be surprised to learn that the word “machine” also has a different meaning in physics: a machine is something that makes work easier to do by changing a force. We will discuss simple and complex machines in more detail in the section on mechanical comprehension, since you are more likely to see questions about those topics in that section of the ASVAB.

Energy also has a different definition in science than it does in everyday life. In physics, energy is defined as the ability to do work. Remember that work is using force to move an object. We can think about two different forms of energy: potential energy and kinetic energy. Potential energy refers to the energy that is stored in matter. A common household battery is a good example of this. Kinetic energy is the energy of motion. When something is moving, it has kinetic energy. We can also think of energy as taking on seven different forms. See Figure Six, which lists these seven forms of energy:

Figure Six: Forms of Energy



Energy can be converted from one form to another. For example, there is chemical energy in fossil fuels, including coal. When the coal is burned, it is converted to thermal energy. Any of the six forms of energy can be converted into the other forms.

Let's focus on the ways that heat moves between objects. If particles are touching and thermal energy—which is heat energy—is transferred between them, this is called conduction. If the particles are in a fluid and thermal energy is transferred, this is called convection. And radiation is the term used when heat transfers through the air or through a vacuum.

This concludes our review of general science topics.

Key Take-Aways

One. The scientific method is the process scientists use to determine facts. The steps of the process are: make an observation, ask a question, form a hypothesis, test the hypothesis, analyze the data, and reach a conclusion.

Two. Be familiar with the units and conversions used in both the standard system and the metric system.

Three. The four layers of the Earth are the crust, mantle, outer core, and inner core. The continents move because of plate tectonics.

Four. The three kinds of rocks are igneous, sedimentary, and metamorphic.

Five. The atmosphere is necessary for life on Earth.

Six. Be familiar with the rock cycle and the water cycle.

Seven. Tides are caused by the moon, and eclipses are caused by the relative locations of the Earth, moon, and sun. Seasons occur as a result of the tilt of the Earth's axis.

Eight. Cells are the basic unit of life; they contain a membrane, cytoplasm, ribosomes, and DNA.

Nine. The major systems of the human body are the urinary, immune, skeletal, reproductive, respiratory, nervous, muscular, integumentary, endocrine, lymphatic, digestive, and cardiovascular systems.

Ten. Homeostasis is the term used to describe the body's efforts to maintain stability.

Eleven. All living things are divided in the classification system. In the animal kingdom, animals with backbones are in the phylum called Chordata. The main classes of chordates are: amphibians, reptiles, birds, mammals, and fish.

Twelve. The environment in which an animal lives is called an ecosystem. A food chain describes how energy moves through the ecosystem. Similar ecosystems are called biomes.

Thirteen. The four states of matter are solid, liquid, gas, and plasma.

Fourteen. The basic building block of all substances is the atom, which consists of three main kinds of particles: neutrons, electrons, and protons.

Fifteen. Energy is defined as the ability to do work. Potential energy is energy that is stored in matter; kinetic energy is the energy of motion. Energy can be converted from one form to another.

QUIZ

1. Which of these is a chemical change?

A. ice melting

B. a shirt ripping

C. dissolving salt in water

D. frying an egg

Answer: D. Option A is a change of state from a solid to a liquid, which is an example of a physical change, not a chemical change. Ripping a shirt is also a physical change, as is dissolving salt. But cooking an egg is a chemical change because the proteins in the egg are changed when they are heated.

2. Which of these is true of mammals?

A. has feathers

B. lays eggs

C. has hair or fur

D. undergoes metamorphosis

Answer: C. Only a mammal has hair or fur; mammals do not have feather or metamorphose. Mammals also give birth to live young; they don't lay eggs.

3. Zero degrees Celsius is equal to which of the following?

A. zero degrees Fahrenheit

B. thirty-two degrees Fahrenheit

C. one hundred degrees Fahrenheit

D. two hundred and twelve degrees Fahrenheit

Answer: B. Celsius and Fahrenheit are two different scales used to measure temperature, and the freezing point of water is zero degrees Celsius and thirty-two degrees Fahrenheit.

4. Which of these options describe the cause of an eclipse?

A. the Earth's axis tilts

B. the moon is directly between the sun and the Earth

C. the sun is between the moon and the Earth

D. the Earth rotates once per day

Answer: B. Eclipses are caused by the positioning of the Earth, moon, and sun in a direct line so that the sun's light is blocked from view.

5. The brain is part of which body system?

A. muscular

B. endocrine

C. nervous

D. reproductive

Answer: C. The brain is part of the nervous system.

6. What regulates the flow of material into and out of a cell?

A. neutrons

B. cytoplasm

C. nucleus

D. membrane

Answer: D. The membrane is the barrier between a cell and its environment, so it is the membrane that regulates the flow of materials into and out of the cell.

7. What are the three main nutrients that humans require?

A. fats, salts, and sugars

B. protein, dairy, and grains

C. carbohydrates, fats, and protein

D. vegetables, fats, and vitamins

Answer: C. The three main nutrients are carbohydrates, fats, and protein.

8. Which biome has little precipitation and vegetation?

A. marine

B. grassland

C. desert

D. tropical rainforest

Answer: C. A desert has very little precipitation, as rain or snow, and therefore has very little vegetation.

9. Which of these is responsible for high and low tides on Earth?

A. the sun

B. the atmosphere

C. the moon

D. clouds

Answer: C. The pull of gravity from the moon is responsible for tides on Earth.

10. Where would you look for information about an element?

A. metric conversion chart

B. periodic table

C. Punnett square

D. solar system model

Answer: B. The periodic table is a way of organizing the elements according to their characteristics, and so it contains information about each element.

ARITHMETIC REASONING (AR)

There are actually two math sections on the ASVAB: one is called mathematical knowledge and the other is called arithmetic reasoning. The arithmetic reasoning section asks you to apply the basic math operations, while the mathematics knowledge tests more advanced math concepts, such as square roots and basic geometry and algebra. In this section, we will prepare for the arithmetic reasoning test, and in the next section, we will prepare for the mathematics knowledge test.

The arithmetic knowledge test will have sixteen questions to answer in thirty-nine minutes if you are taking it on a computer or thirty questions to answer in thirty-six minutes if you are taking the written version. For both versions, you are not allowed to use a calculator. But you will be given scratch paper to use.

To give you a sense of the kinds of questions that you will see on this section, let's consider the sample questions on the official ASVAB website. The first one asks you to determine how many times a tire will rotate in half an hour if it rotates a specific number of times in a minute. The second question describes a town where the citizens had a choice of two candidates to vote for. You are told that a certain proportion voted for the first candidate and then asked how many voted for the other candidate. You are given the population of the town. In the third question, you are asked how much a motorcycle will be worth after one year; you are given its starting value and the depreciation rate.

As you can see, these questions use basic math concepts such as multiplication, division, and percentages. The trick to this section is knowing how to apply those concepts to the scenario that you are given. We will review both the basic math concepts and strategies for knowing how and when to apply them in this section. You'll get the most out of this section and the next section if you follow along with paper and a pencil and work through the problems yourself.

First, you need to be comfortable doing addition, subtraction, multiplication and division problems without a calculator. You should know that if a problem asks you for a "total" or a "sum," you need to add. A "difference" means that you subtract. A "product" means that you multiply, and a "quotient" means you divide. Let's try three sample problems.

One. Three-quarters of the people coming to Jaime's party friends prefer pizza, while the rest prefer hamburgers. If twenty-four people are coming and each hamburger eater will eat one hamburger, how many hamburgers should Jaime order?

To solve this problem, begin by noting that one-quarter of the people prefer hamburgers. You can determine this since the problem stated that three-quarters prefer pizza and the rest prefer hamburgers. You should write the fraction one over four on your scratch paper. You may want to write the letter "H" next to the numerator—that's the number on the top or, in this case, the number one—to help you remember what it is that one over four represents. What this fraction means is that out of every four people, one of them wants a hamburger. Because the problem tells us that there is a total of twenty-four people, write a fraction next to one over four that has a twenty-four as the denominator—that's the number on the bottom. Put an equals sign between the fractions, since what we want to know is how many people out of twenty-four will eat hamburgers. Now the next step is to determine what the numerator of the second fraction should be. To determine this, look at the denominators and ask yourself, "What do I multiply four by in order to get twenty-four?" The answer to that question is six. Since the fractions are supposed to be equal, you will need to multiply the numerator by the same number. So, you multiply one times six, and the answer is six. Six should be the numerator of the second fraction. This means that six people will want hamburgers, and since the problem tells us that each person will eat one hamburger, this means that Jaime should order six hamburgers.

Two. Elena buys a condo for ninety-two thousand, four hundred and twenty-four dollars. One year later, the condo is worth eight percent more. How much is the condo then worth?

There are a few different ways that you can solve this problem. You could calculate eight percent of the starting amount and then add it to the starting amount, and this would give you the new price. Or, you could multiply the starting amount by one hundred and eight percent, since the starting value of the home is equal to one hundred percent and the value increased by eight percent, which means that the value of the home after a year was one hundred and eight percent of the starting price. Either of these approaches should give you the correct answer.

Let's use the second approach, since it involves fewer steps. Remember that you cannot do a mathematical operation with a percentage until you convert it to a decimal. To do this, you move the decimal place in the percentage two places to the left. This means that the decimal equivalent of one hundred and eight percent is one and eight one-hundredths, or one point zero eight. The next step is to multiply the starting value times one point zero eight. That results in the answer ninety-nine thousand, eight hundred and seventeen, and ninety-two hundredths.

Three. Each box in a warehouse contains forty-eight smartphones. If there are one hundred and seven boxes, how many smartphones are in the warehouse?

To solve this problem, you need to multiply forty-eight times one hundred and seven to determine the total number of phones. The result is five thousand, one hundred, and thirty-six.

As you can see from these sample problems, you need to be able to add, subtract, multiply, and divide large numbers with ease. Remember that you will have scratch paper, but you will not have a calculator. If your skills in these areas are a bit rusty, you can review them and practice using them on a website such as Khan Academy, CK12, or Math Is Fun. They have explanations for all of the math concepts covered on the arithmetic reasoning test and the mathematics knowledge test.

You will also need to know how to do the four basic math operations with negative numbers. Sometimes, remembering what to do with negative numbers can be a bit tricky. Here is a strategy that can help you: when you are adding or subtracting negative numbers, it can be helpful to think about negative numbers as being a debt. Think about the problem negative four plus negative three. Imagine that you were four dollars in debt, and then you spent three more dollars. What would your debt be in that case? It would be a seven-dollar debt. This means that the answer to negative four plus negative three is negative seven. Now think about the problem three plus negative two. Imagine that you had three dollars and then you took on a two-dollar debt. How much money would you have? You would have one dollar, which means that three plus negative two equals one. Now let's think about subtraction. What is three minus

negative four? Since this is a subtraction problem involving a negative number, you can think about this as taking away a debt. The debt is the negative number and we are taking something away because this is a subtraction problem. If you have three dollars and you take away a debt of four dollars, then you would have seven dollars. If you find this confusing, here is another way to think about subtracting a negative number: any time that there are two subtraction signs in a row in a problem, as there are in the problem three minus negative four, you can, in effect, combine the two negative signs to make a positive sign. This means you can treat the problem three minus negative four as the same as three plus four. Now let's review multiplication and division with negative numbers. Fortunately, there are two simple rules that you can remember, and they work for both multiplication and division problems:

One. If both signs are the same, the answer is positive.

Two. If the signs are different, the answer is negative.

Let's try some sample problems to see these rules in action.

First, what is twenty times negative ten? The signs are different since twenty is positive and ten is negative, which means that the answer is negative. In this case, it is negative two hundred.

Second, what is negative twenty times negative ten? The rule states that if the signs are the same, then the answer is positive, so negative twenty times negative ten equals two hundred.

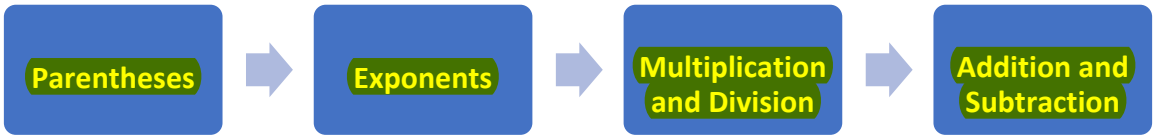
Third, what is negative ten divided by two? Since the sign of negative ten is different than the sign of two, we know that the answer will be negative. In this case, it is negative five.

Fourth, what is negative ten divided by negative two? Since the signs are the same, the answer is positive. This means that the answer is five.

Another concept that is important to understand is the correct order of operations. When you read words, you always just go from left to right. But you can't do that in a math problem, or sometimes you will get the wrong answer. Instead, you have to do the operations in a certain order. First, you do anything that is inside of parentheses. Then, you do any exponents. Then,

you do any multiplication or division. Finally, you do any addition or subtraction. Some people use the fake word "PEMDAS" (which is spelled P-E-M-D-A-S) to help them remember the order of operations since each letter in "PEMDAS" stands for the operations in order: parenthesis, exponents, multiplication, division, addition, and subtraction. Look at Figure Seven to help you remember the order of operations:

FIGURE SEVEN: ORDER OF OPERATIONS



Let's try a sample problem that requires the proper order of operations to be followed in order to get the correct answer.

What is the solution to three minus open parentheses five plus two times seven close parentheses? Now, if you just do this problem in order from left to right, you will get the wrong answer. The way to solve it is to begin with what is inside the parentheses. So let's ignore the three minus for now. When you look at what is inside the parentheses, you will see that there is an addition problem and a multiplication problem. It is important that you do the multiplication first. Two times seven equals fourteen. Now, we have inside the parentheses five plus fourteen. That equals nineteen, so the value of everything inside the parentheses is nineteen. Now we can focus on what is outside of the parentheses. We have three minus nineteen, which equals negative sixteen.

Let's try one more sample problem that relies on using the correct order of operations. Get ready, because this is a complicated one. What is three plus five times eight divided by open parentheses three minus one close parentheses plus four to the second power? Remember that if you just go from left to right, you will often get the wrong answer. Instead, you need to use the proper order of operations. Remember that the first thing that you should do are parentheses. In this problem, we do have parentheses. Inside the parentheses, we have three minus one. So that is the first thing that we need to do. Three minus one equals two, so we can

replace what is inside the parentheses with two. Now, our problem reads three plus five times eight divided by two plus four to the second power. The second step is to do any exponents. This problem has an exponent since the final term is four to the second power. Remember that exponents mean that you multiply the number by itself, and you do this the number of times that the exponent tells you to do it. So, four to the second power is the same as four times four, which is the same as sixteen. This means that we can replace the final term with sixteen. Now, our problem reads three plus five times eight divided by two plus sixteen. The next step is multiplication and division. You do these going from left to right. This means that the next thing that we need to do is to multiply five times eight. Five times eight equals forty. Our problem is now three plus forty divided by two plus sixteen. We still have another division problem to work out. We need to divide forty by two. That equals twenty, so our problem now reads three plus twenty plus sixteen. The final step is to do any addition or subtraction problems, moving from left to right. So, three plus twenty equals twenty-three. Twenty-three plus sixteen equals thirty-nine. That is the answer.

Another concept that you should be familiar with is the difference between prime and composite numbers. The definition of a prime number is a number whose only factors are itself and one. That means that the only numbers that you can multiply together to get the number are itself and one. On the other hand, a composite number is a number that has other factors—other numbers that you can multiply together to get the number. Let's look at some examples to see how this works.

Is the number twenty-four prime or composite? To answer this question, think to yourself: what numbers can be multiplied together to get twenty-four? Of course, there is one and twenty-four. If those were the only numbers that you could multiply together to get twenty-four, then we would conclude that twenty-four is prime. But there is also two and twelve, and three and eight, and four and six. Because there are more factors than just one and twenty-four, then this number is composite. You might find it helpful to think of the word "composite" as meaning "composed" of certain numbers.

Let's try another. Is thirteen prime or composite? What numbers can you multiply together to get thirteen? The only numbers are one and thirteen. That means that thirteen is prime.

Let's move on to percentages. You will need to be comfortable working with percentages. Remember that when we talk about percentages, we are talking about a certain number of parts out of one hundred parts. For example, if you drink two percent milk, that means that out of every one hundred units of milk, two of them are fat. If you drink one percent milk, that means that one out of one hundred units of the milk content is fat. You can have percentages of more than one hundred. For example, if you get a one hundred and fifty percent raise at work, that means that your old pay is doubled plus another half of your old pay. If you were making ten dollars an hour, you are now making twenty-five dollars an hour. An important thing to remember with percentages is that you cannot simply plug a percentage into a math problem. You always need to convert it to a decimal first. The good news is that it is easy to do this. All you need to do to convert a percentage to a decimal is to move the decimal point over two places to the left. Here are two examples:

Forty-three percent is equal to point four three.

Eight percent is equal to point zero eight.

Think about that second example for a minute. It's really important to you converted eight percent to point zero eight—it isn't the same as point eight. If you always move the decimal two places to the left, you'll be fine. Remember, you can never plug a percentage into a math problem and then add, subtract, multiply, or divide it. Instead, you need to convert it into a decimal first. Then, you can do mathematical operations on it.

Sometimes, you need to do just the opposite and convert a decimal into a percentage. If you remember this rule, converting decimals to percentages is pretty easy, too: you just move the decimal two places to the right. Here are two examples:

One point thirty-eight is equal to one hundred and thirty-eight percent.

Point thirty-six is equal to thirty-six percent.

Next, let's review ratios. A ratio tells you the relative sizes of two things. For example, maybe the recipe that you usually use to make pancakes has one cup of flour and two eggs. That means that the flour to egg ratio is one to two. If you wanted to double the recipe, you'd put two cups of flour and four eggs. The ration would still be one cup of flour to two eggs, even though the amounts are different. So the benefit of a ratio is that it lets you think about the relationship between two numbers, even when their quantities change. There are actually three different ways that you can write a ratio. The first one is to put a colon in between the two numbers. The second is to make a fraction where one of the numbers is the numerator and the other number is the denominator. And the third is to put the word "to," spelled T-O, in between the two numbers. Let's do a practice problem with ratios.

Jaime can read ten pages in fifteen minutes. How long will it take him to read a two-hundred-page book?

This problem gives you a ratio of pages to minutes. In this problem, that ratio is ten to fifteen, since Jaime can read ten pages in fifteen minutes. One way to solve this is to write the first ratio as a fraction of ten over fifteen. To help keep things clear, you might write the word "pages" next to the numerator and the word "minutes" next to the denominator. Now, set up a second fraction. Its numerator should be two hundred, since the problem asked us about a two-hundred-page book. We don't have the denominator, since that is what we are solving for. The easiest way to think through this problem is to look at the numerators, and ask yourself, "What would I multiply ten by to get two hundred?" The answer is twenty. Since we want the second fraction to be equal to the first fraction, then since we multiplied the numerator of the first fraction by twenty, we will want to multiply the denominator by twenty as well. Since fifteen times twenty equals three hundred, the denominator of the second fraction is three hundred. This means that it will take Jaime three hundred minutes to read a two-hundred-page book.

We have already reviewed some aspects of fractions, but there are a few other things that you should know about them. First, be sure that you can simplify fractions. This means that you divide both the numerator and the denominator by the largest number that you can divide both of them by. Or, to make things a little easier, you can start simplifying by picking any

number that you can divide both the numerator and the denominator by, and then repeat the process until you can't find another number to divide them by.

For example, think about the fraction ten over sixty. To simplify this fraction, we can start by dividing both parts of the fraction by five. Our fraction would then be two over twelve. We can then divide both parts by two. Now our fraction is one over six. We can't simplify any more than that.

You also need to be able to convert mixed numbers to improper fractions and improper fractions to mixed numbers. A mixed number is a number that has a fractional part and a whole number, and an improper fraction is a number where the numerator is larger than the denominator. Let's look at examples of these fractions to see how the conversions work.

Think about the fraction eleven over five. We call that an improper fraction because the numerator is larger than the denominator. To convert it to a mixed number, we need to divide eleven by five, and in our answer, we need a remainder—not a decimal. When we divide eleven by five, we get two with a remainder of one. Since our answer is two, our answer will have a two for the whole number. And since our remainder is one, our answer will have a one for the numerator. The denominator stays the same. So the process for converting an improper fraction to a mixed number is to divide the numerator by the denominator, with the resulting whole number being the answer and with the remainder as the new numerator.

Let's try another example. Let's convert thirty-one over seven to a mixed number. We know that thirty-one over seven is an improper fraction because the numerator is larger than the denominator. We begin by dividing thirty-one by seven. This gives us four and a remainder. The nice thing about this process is that you do not need to calculate the remainder. Because thirty-one divided by seven is four (plus a remainder), we know that four will be the whole number for the mixed number. At this point, it is helpful if you write down the four and you write the denominator next to it. When we convert from an improper fraction to a mixed number, the denominator always stays the same, so the denominator is going to be seven. The reason for writing this down is that the next step is to multiply the denominator times the whole number.

In this case, we multiply seven times four. That gives us twenty-eight. Think of this number as the number of pieces that we have already accounted for in the whole number. We need to account for thirty-one pieces, since thirty-one is the original numerator, and by making four our whole number, we have accounted for twenty-eight of those pieces. How many pieces are remaining? We can figure that out by subtracting twenty-eight from thirty-one. That results in three. That three is our numerator. So, our answer is four and three-sevenths.

To convert a mixed number to a fraction, you reverse that process. Think about the fraction three and five eighths. To convert that to an improper fraction, you multiply the whole number by the denominator and then add that sum to the numerator. Since three times eight equals twenty-four, you would add twenty-four to five. That equals twenty-nine, so the new numerator is twenty-nine and the answer is twenty-nine over eight.

Let's try one more sample problem. Let's convert ten and two-eights to an improper fraction. To begin, we multiple the denominator times the whole number. Ten times eight equals eighty. Then, we add that eighty to the numerator. Eighty plus two equals eighty-two. Eighty-two is our new numerator. Our fraction is eighty-two over eight, and that is the improper fraction that is equal to ten and two-eighths.

Now let's review the four basic operations with fractions. To add or subtract fractions, their denominators have to be the same. Note that this is not true for multiplying and dividing fractions: you can multiply or divide fractions with different denominators, and we will soon review how to do that. But to add or subtract, the denominators have to be the same. If they are not the same, you will have to change one or more of the fractions so that they are the same. For example, let's say that you wanted to add three-eighths plus two-fifths. The very first question you should ask yourself when you are adding or subtracting fractions is, "Are the denominators the same?" In this case, they are not. So you will have to address that first. The easiest way to do this is to multiply the denominators by each other. Our denominators are eight and five, so we multiply them together and we get forty. Rewrite the problem with two new fractions that each have a denominator of forty. The next step is to figure out what the new numerators are. Let's begin with the first fraction. Since we multiplied its denominator by

five, we will need to multiply its numerator by five. Since three times five equals fifteen, the new numerator is fifteen. Now think about the second fraction. We multiplied its denominator by eight, so we need to multiply its numerator by eight. Two times eight equals sixteen, so our new numerator is sixteen. Now we have fractions that are equivalent to our original fractions, and they have the same denominator, so we can add them. To add fractions, we keep the denominator the same and add the numerators. Since fifteen plus sixteen is thirty-one, our numerator will be thirty-one. Since we keep the denominator the same, the denominator will be forty. So the answer to the question is thirty-one over forty. We would follow the same procedure for subtraction except, of course, we would subtract the numerators instead of adding them.

Let's try a practice problem that involves subtracting fractions. What is nine-elevenths minus three-fourths? Remember that the very first thing that you need to do when you subtract fractions is to ask yourself, do these fractions have the same denominator? If they do, you are fine. If they do not, you need to make them the same. The most reliable way to do this is to multiply them times each other. Eleven times four equals forty-four, so the denominator for both of our fractions is forty-four. Of course, if we are going to multiply a denominator by something, then we have to multiply the numerator by the same number that we multiplied the denominator by so that our new fraction will be equivalent to our old fraction. Let's look at the first fraction. It was nine-elevenths, but we changed the denominator to forty-four. To get that forty-four, we had to multiply the denominator by four, since eleven times four equals forty-four. Since we have multiplied the denominator by four, we need to multiply the numerator by four. Nine times four equals thirty-six, so our fraction is now thirty-six over forty-four. Let's take a look at the second fraction. The original denominator was four, but we changed it to forty-four. Since we multiplied it by eleven, that means that we also have to multiply the numerator by eleven. The original numerator was three. Three times eleven equals thirty-three, so our new fraction is thirty-three over forty-four. Our problem now reads thirty-six over forty-four minus thirty-three over forty-four. Now, when we ask ourselves the question, "Are the denominators of these fractions the same?" the answer is yes. This means that we can proceed with the subtraction problem. When we add or subtract fractions, the

denominator stays the same. So the denominator of our answer will be forty-four. That step is easy. Next, we need to subtract the numerators. This gives us thirty-six minus thirty-three. That equals three. So, our answer is three over forty-four. In some situations, it may be possible to reduce the answer. But that is not the case here, so we are finished with this problem.

Now, multiplication is different. It's fine if the denominators are different. To multiply fractions, you simply multiply the numerators and then multiply the denominators. So, for example, if we need to multiply two-sevenths times three-eighths, we begin by multiplying the numerators. Since two times three equals six, the numerator for our answer will be six. Since seven times eight is fifty-six, the denominator in our answer will be fifty-six. So, the answer is six over fifty-six. We can reduce that to three over twenty-eight.

Let's try one more practice problem. What is two-thirds times one-ninth? Remember, we do not need the denominators to be the same in order to multiply fractions. Of course, if you were to make them the same, nothing horrible would happen—you would still get the correct answer, but you would waste a lot of time because first you would have to set the denominators equal to each other and then, at the end of the problem, you would have a lot of reducing to do. So remember: to multiply or divide fractions, you do not care if the denominators are the same. You simply multiply the numerators and then multiply the denominators. In this case, two times one equals two, so our numerator is two. Looking at the denominators, three times nine equals twenty-seven, so our denominator in the answer will be twenty-seven. Our answer is two over twenty-seven. We cannot reduce that, so we are finished with this problem.

Now let's review how to divide fractions. Again, it is fine if the denominators are different. To begin, you will invert the second fraction. This means that you switch the numerator and the denominator. Let's look at an example of this part first. If I gave you the fraction two over three and asked you to invert it, the answer would be three over two. You simply swap out the numerator and the denominator. There is an explanation for why you do this when you divide fractions, but you don't need to know it. Some people memorize the phrase, "Ours is not to reason why—ours is to invert and multiply!" Math teachers tend not to like this because it is

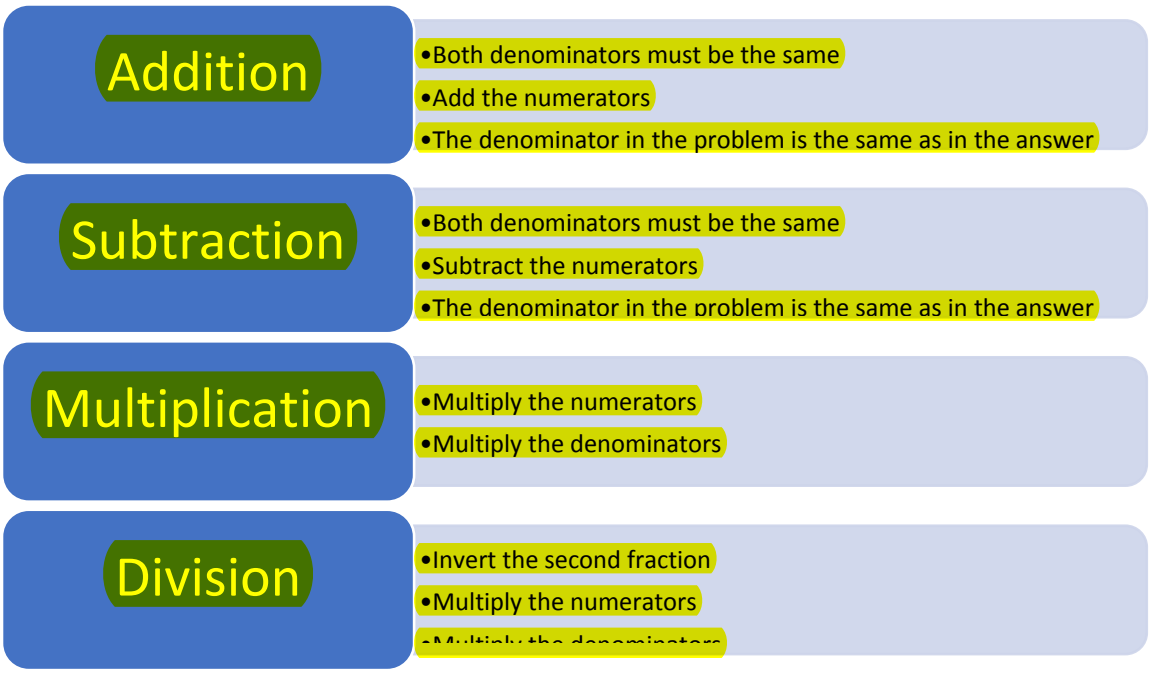
important to understand why you do what you do. But you don't need to understand the "why" part to do well on the ASVAB. You just need to remember that to divide fractions, you invert the second fraction and then you multiply. Let's try an example. Think about the problem five-eighths divided by two-thirds. The first step when you divide fractions is to invert the second fraction, which means that the two-thirds becomes three over two. Now we can multiply the fractions. So, our problem is now five-eighths times three over two. Fife times three is fifteen, so the numerator of the answer is fifteen. Eight times two is sixteen, so the denominator of the answer is sixteen. The answer is fifteen over sixteen.

Let's try one more sample problem. What is two over six divided by three over two? Remember: invert and multiply. That turns our problem into two over six times two over three. We multiply our numerators, and that results in a four. We multiply our denominators, and that results in eighteen. This means that our answer is four over eighteen. We can reduce that because we can divide four by two and we can divide eighteen by two. This gives us two over nine.

A problem on the ASVAB may or may not specifically ask you to reduce the answer, but if you solve a problem with fractions and you don't see the answer that you got among the answer choices, that is a good sign that you need to reduce or perhaps convert an improper fraction to a mixed number.

Use Figure Eight to review the mathematical operations that involve fractions:

Figure Eight: Operations with Fractions



You should also know how to calculate averages. The basic procedure is simple: you add up all of the numbers in the set. Then, you divide by the number of numbers. For example, if you want to find the average of five quiz grades, you add them all up and then you divide by five. Let's try a sample problem.

Juan earned the following scores in his chemistry class: ninety-eight, eighty-two, seventy-nine, ninety-one, eighty-seven, and ninety-three. What was his average grade for the class? We need to follow two steps in order to calculate an average. The first step is to add all of the numbers together. In this case, if we add together all of Juan's grades, we get five hundred and thirty. That's the first step. The second step is to divide that sum by the number of grades. Juan had six grades, so we need to divide five hundred and thirty by six. When we do that, we get eighty-eight point three repeating. That is our average.

This concludes our review of the most important math concepts for you to know for the ASVAB. Now, we will review some strategies for using these math concepts. The thing to know about

this section of the ASVAB is that it will ask you to apply these math concepts to real-world problems. This can sometimes be a little tricky.

First, if you find yourself stumped on a problem, you can try working backwards. This means that instead of trying to solve the problem itself, you test each of the answer choices and see which one works. Let's try an example of this. Think about this problem:

Lynn bought a new car last year. The car dealer had added ten percent to the wholesale price to get the retail price. Then, Lynn bought the car when the dealer offered her one thousand dollars off of the price. But Lynn wanted a special options package, which added another seven hundred dollars to the price. If Lynn paid twenty-five thousand dollars for the car, what was the wholesale price?

The answer choices are twenty-three thousand dollars, twenty-four thousand dollars, twenty-five thousand dollars, and twenty-six thousand dollars. Now, you may be able to solve this problem as it is written, but we want to test the strategy of working backwards, which is something that you can try if you do not know how to solve the problem as written. So we will begin with the answer choices. Working backwards means that we will plug the answer choices into the problem and test them until we find one that works. You could start with the first option and go in order, but it is usually better to start in the middle. If you start in the middle and the first choice gives you an answer that is too big, then you should try the smaller answer options. And if it is too small, you should try the larger options. So starting in the middle can sometimes save you time since you won't always have to try all of the options. So, let's start with one of the answer options in the middle, twenty-four thousand dollars. If that is the wholesale price, then the dealer will add ten percent to it to get the retail price. Ten percent of twenty-four thousand is two thousand and four hundred, which means that the retail price would be twenty-six thousand and four hundred. The dealer took one thousand dollars off of the price, which then brought the price to twenty-five thousand and four hundred. Then, Lynn added seven hundred dollars in options, which means that the price was twenty-six thousand and one hundred dollars. Since the problem tells us that Lynn paid twenty-five thousand dollars for the car, we know that this cannot be the correct answer. We can eliminate it. We also know

that starting at a wholesale price of twenty-four thousand dollars gave us a value that was too high, which means that the answer must be less that twenty-four thousand. In other words, it has to be twenty-three thousand. You can work it out and see that if the wholesale price was twenty-three thousand, then Lynn would have paid twenty-five thousand, so it is the correct answer.

From this example, you should see that even if you do not know how to solve a problem, all hope of getting the correct answer is not lost. Remember: the correct answer is always there in front of you, as one of the answer options, since these are multiple choice questions. When all else fails, you can simply test the answer options to see which one works. Of course, this takes more time, usually, than simply solving the problem, since you will need to test up to four answer choices to see which one works. That is sort of like having to do four questions to get one right answer. That means that it can take a lot more time than not using the approach of working backwards. So, only work backwards in situations where you do not know how to solve the problem the usual way, because the cost of working backwards is that it generally takes more time to get to the correct answer.

Here is the second strategy. To do well on this section, you will also need to be able to apply the mathematical operations that we have reviewed to the problems on the test, which are normally word problems that ask you to apply what you know to a specific situation. Here are a few techniques that can help you do that.

One. Wherever possible, draw a picture on your scratch paper. Make it as simple as possible so that you do not waste time. Drawing a picture can help you understand and visualize what needs to happen in the problem. Think about a problem that asks you about a ratio for mixing paint. That can be hard to keep straight in your head, because you will be working with at least four numbers and possibly more. So, draw something. It can be a simple circle to represent the paint container, as if you were looking down on it from above. And if you are told that the ratio of color to paint is one to ten, then you can write one to ten inside of that circle. If you are asked how many units of color you would need for eight gallons of paint, it then becomes really easy to visualize eight of those paint containers and think about how many units of color that

would involve. So, again, wherever it is possible, draw a picture. Make it as simple as possible but draw a picture or a diagram to help you. If you find that negative numbers are confusing to you, you can draw a simple number line to keep track of what is going on in the problem.

Two. Think about translating a word problem as if you were translating from one language to another. The language of the word problem is English, but the language you need to use to solve the problem is the language of math. Thinking about it as a translation can help you transition from a word problem to a math problem. And the single most important thing you should know is that the word "of" means to multiply. Think about this sample problem:

What is ten percent of one hundred?

Let's translate that problem word-by-word from English to math. The word "what" is an unknown, so that can be represented by a variable. To translate, write the letter X. The word "is" can be represented by an equals sign. So our translation should read X equals. Ten percent needs to be changed to a decimal in order to be used in a math problem, so our equation now reads X equals point one, but we aren't done yet. The word "of" means to multiply, so our equation is now x equals point one times. The final term to add is the one hundred. So our math translation is x equals point one times one hundred. Now we could solve that problem. Sometimes, a word problem can feel overwhelming because it isn't immediately clear how to change the situation into a math problem. But thinking about it as a translation exercise—the same as if you were translating from Spanish into English, for example—can make it less intimidating to work with.

A **third** strategy that you can try is to estimate. For example, let's say a problem requires you to add together five purchases, all of which are in the hundreds of dollars, and you are running out of time. You could try rounding the purchases to the nearest ten dollars and then adding those, which will save you the trouble of adding the hundredths, tenths, and one's places. You may be able to eliminate several answer choices using the process of elimination just based on working through the problem with estimates. Estimation can also be a useful reality check. In other words, if you are not sure if you have done a problem correctly, you can estimate it to

determine if your answer makes sense. You can use estimation to help determine if you have made errors in either setting up the problem or in performing the mathematical operations in the problem.

Four. Here's another strategy. It's going to sound a little strange, but it usually works. If you are stumped at how to set up a problem, temporarily replace the numbers in the problem with really easy numbers. Once you do this, you can usually quickly figure out how to solve the problem. Then, when you know what to do, return to the original numbers in the problem and solve it. Think about this example:

Jenn wants to share her one thousand, three hundred, and eighty-four photos evenly between her nineteen nieces and nephews. How many will each person get?

Hopefully you know how to set up that problem, since it is a fairly straightforward division problem. But if you didn't, you might find it helpful to replace the large and difficult numbers in the problem with easier numbers and then ask yourself what to do. So let's replace the numbers. Now the problem reads: Jenn wants to share her ten photos evenly between her five nieces and nephews. How many will each person get? That problem is very easy to visualize—you could even draw ten little squares to represent the photos if you needed to. It should be obvious that each person would get two photos because you divide ten by five. Now that you know that the proper thing to do is to divide the number of photos by the number of people, you can return to the original numbers in the problem and use them to solve the problem. So, again, if you find yourself stumped about how to set up a problem, temporarily replace the numbers in the problem with really easy numbers. This will usually make it clear to you how to solve the actual problem.

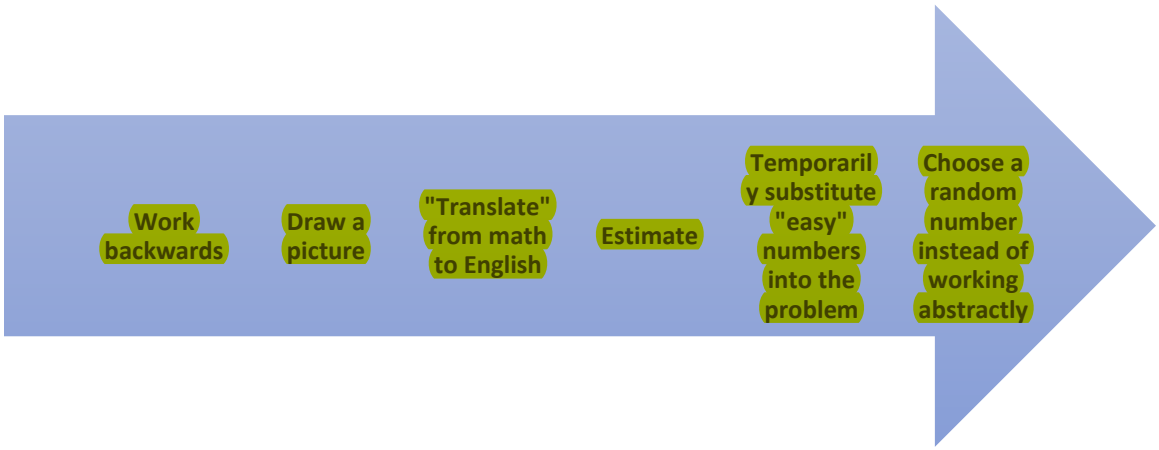
And there is a variation on this strategy that you might find helpful. You can make some problems easier by choosing a number to use instead of working abstractly. Let's say that you have a problem like this:

In Mrs. Martinez's class, one-quarter of the students prefer chocolate ice cream, one-half prefer vanilla, and the rest chose strawberry. What percentage of the class chose strawberry?

If you didn't know how to solve it, you could make up a number of students in the class and work with that. Be sure to pick an easy number, like one hundred. That's an especially good choice in this case, since the answer needs to be a percentage. It doesn't matter that it isn't realistic to think that there would be one hundred people in a class. So if there are one hundred students, then twenty-five prefer chocolate, fifty prefer vanilla, and twenty-five chose strawberry. If twenty-five out of one hundred chose strawberry, then twenty-five percent chose strawberry.

Figure Nine summarizes the strategies that you can use if you are stumped by a math problem:

Figure Nine: Strategies for Math Problems When You Don't Know What to Do



This concludes our review of basic math concepts.

Key Take-Aways

One. Be prepared to do addition, subtraction, multiplication, and division without a calculator.

Two. If you are multiplying or dividing numbers with different signs, the answer will be negative. If the numbers you are multiplying or dividing have the same sign, the answer will be positive.

Three. The order of operations is: parentheses, exponents, multiplication and division, addition and subtraction.

Four. Be prepared to convert decimals to percentages and fractions and vice versa.

Five. A ratio tells you the relative sizes of two things.

Six. Simplify fractions by dividing both the numerator and the denominator by the largest number that you can divide both of them by.

Seven. You need to be able to convert mixed numbers to improper fractions and improper fractions to mixed numbers.

Eight. To add or subtract fractions, their denominators have to be the same. Then, keep the denominator the same and add (or subtract) the numerators.

Nine. To multiply fractions, multiply the numerators and then multiply the denominators.

Ten. To divide fractions, invert the second fraction, then multiply.

Eleven. To average, you add up all of the numbers then divide by the number of numbers.

Twelve. If you get stuck, try testing each answer choice to see which one works.

Thirteen. Wherever possible, draw a picture on your scratch paper.

Fourteen. Think about translating a word problem as if you were translating from “English” to “math.” The most important thing you should know is that the word “of” means to multiply.

Fifteen. If you get stuck, try estimating or replacing the numbers in the problem with easier numbers.

Sixteen. You can make some problems easier by choosing a number to use instead of working abstractly.

QUIZ

1. **There are six servers working at a restaurant. The first has three tables, the second has four tables, the third has one table, the fourth has five tables, the fifth has four tables, and the sixth has three tables. What is the average number of tables, rounded to the nearest whole number?**

   A. two

   B. three

   C. four

   D. five

   Answer: B. To solve this problem, we have to find an average. To do this, we add up all of the numbers and divide them by the number of numbers. Three plus four plus one plus five plus four plus three equals twenty. Since there are six numbers, we divide twenty by six. This equals three with a decimal of a repeating three. But we need to round. Three rounds down, so our answer is three.

2. **If a dog's heart beats sixty times per minute, how many times will it beat in a quarter of an hour?**

   A. one hundred and twenty-times

   B. nine hundred times

   C. eighteen hundred times

   D. three thousand and six hundred times

   Answer: B. A quarter hour contains fifteen minutes. Since the dog's heart beats sixty times in one minute, if we multiply sixty times fifteen, the answer will tell us how many times the dog's heart will beat in one quarter of an hour. Since sixty times fifteen equals nine hundred, that is the correct answer.

3. **Kate is covering her bedroom in carpet squares. Each square is ten inches by ten inches. If the bedroom is ten feet by ten feet, how many carpet squares will she need?**

A. one hundred

B. one hundred and twenty

C. one hundred and forty

D. one hundred and forty-four

Answer: D. The trick to getting this question correct is to notice that the size of the carpet squares is given in inches, but the dimensions of the bedroom are given in feet. You will get the wrong answer if you do not convert so that the units are the same. If the bedroom is ten feet by ten feet, this means that it is one hundred and twenty inches by one hundred and twenty inches, since there are twelve inches in a foot. If the length is one hundred and twenty inches and the carpet squares are ten inches, this means that it will take twelve carpet squares in a row to cover the floor. This means that you can multiply twelve times twelve to get the number of squares needed. The answer is one hundred and forty-four.

4. **Omar is travelling north at sixty miles per hour. He left his starting point at ten am. Cynthia is traveling south on the same road as Omar. She is travelling at seventy miles per hour, and she left at eleven am. If Cynthia and Omar were five hundred miles apart when they began driving, how far apart will they be at one in the afternoon?**

A. one hundred miles

B. one hundred and twenty miles

C. one hundred and forty miles

D. one hundred and eighty miles

Answer: D. This kind of question is much easier to solve if you draw a picture. Begin with a line going up and down and write 500 miles next to it to indicate the distance between Cynthia and Omar. Since Omar is traveling north, put a dot at the bottom of the line and write Omar next to it. Since Omar starts at ten am, let's see where he is at one pm.

That's three hours. In each hour, he travels sixty miles. That means he travels north a total of one hundred and eighty miles. Draw a dot north of Omar's starting point and write one hundred and eighty next to it. Now draw a dot at the top of the line and write the letter "C" next to it, for Cynthia. She starts at eleven am, so she only travels for two hours by one pm. Since she travels seventy miles each hour, this means that she travels a total of one hundred and forty miles. Draw a dot south of Cynthia's starting point and write one hundred and forty next to it. Now you should be able to see that if we subtract one hundred and forty and one hundred and eighty from five hundred, we will know how far apart Cynthia and Omar are. The correct answer is one hundred and eighty.

5. **LaShawn borrowed fifty dollars from his brother. Two months ago, LaShawn paid back one-fifth of what he owed. The next month, LaShawn paid back twenty dollars. If LaShawn wants to pay back the remainder of what he owes in even amounts over the next four months, how much should be pay each month?**

A. five dollars
B. ten dollars
C. fifteen dollars
D. twenty dollars

Answer: A. Two months ago, LaShawn paid back one-fifth of the fifty dollars that he owed. One fifth of fifty dollars is ten dollars, which means that his debt was then forty dollars. Then, he paid twenty dollars. Forty minus twenty is twenty, so he then owed twenty dollars. If he wants to pay off twenty dollars in even amounts over four months, then we would divide twenty by four and get five. That means he needs to pay five dollars each month.

6. **A gram of protein contains four calories and a gram of fat contains nine calories. A snack with thirty-two grams of protein would have how many calories from the protein?**

A. thirty-two

B. one hundred

C. one hundred and twenty-eight

D. two hundred and eighty-eight

Answer: C. To determine the correct answer, you need to multiply four times thirty-two, since each gram of protein has four calories. Notice that you don't need to use the information that a gram of fat has nine calories in order to solve the problem.

7. **George is going on vacation and needs to travel one thousand and eight miles in two days. If he wants to drive exactly eight hours each day, how fast will he need to drive?**

A. sixty miles per hour

B. sixty-three miles per hour

C. one hundred miles per hour

D. one hundred and twenty-six miles per hour

Answer: B. Since George has two days, he needs to travel five hundred and four miles each day. Since he wants to drive eight hours each day, we can divide five hundred and four by eight and determine that he needs to travel sixty-three miles each hour, so he will need to drive sixty-three miles per hour.

8. **Ricardo is making curtains for his condo. Each window requires three and three-eights yards of fabric. How many yards of fabric will Ricardo need for six windows?**

A. eighteen and three-eighths

B. twenty

C. twenty and one-fourth

D. twenty-one and three-eighths

Answer: C. To solve this problem, we need to first convert three and three-eighths into an improper fraction. That gives us twenty-seven over eight. Now, we multiply the fractions. Twenty-seven times six equals one hundred and sixty-two, so that is our numerator. Eight times one equals eight, so eight is the denominator. We can reduce that to eighty-one over four. Next, let's convert that to an improper fraction. Since there are twenty fours in eighty-one, our whole number will be twenty. That leaves us a numerator of one. So, the answer is twenty and one fourth.

9. Patrice's student loan requires him to pay eight percent of his salary as the amount of the student loan payment. If Patrice's salary is forty-two thousand dollars per year, how much will he have to pay toward his student loans each month?

A. eighty dollars

B. two hundred and eighty dollars

C. four hundred and twelve dollars

D. three thousand, three hundred and sixty-dollars

Answer: B. Eight percent of the salary is three thousand, three hundred, and sixty dollars. But notice that that is the amount per year, and the question asks for how much he has to pay per month. This is why option D is incorrect. We need to divide three thousand, three hundred, and sixty by twelve to determine how much he pays each month. The answer to that is two hundred and eighty, so option B is correct.

10. A soccer team is holding a car wash fund raiser to earn money. They worked for four hours and earned three hundred and twenty dollars. At that rate, how many more hours will they need to work to meet their goal of one thousand dollars in total earnings?

A. six and one-half

B. eight

C. eight and one-half

D. nine

Answer: option C. They need to earn another six hundred and eighty dollars, which we can determine by subtracting three hundred and twenty from one thousand. They have been earning eighty dollars an hour, since three hundred and twenty divided by the four hours that they have worked equals eighty dollars per hour. If we divide six hundred and eighty by eighty, we get eight and one half.

MATHEMATICS KNOWLEDGE (MK)

In this section, you will have twenty minutes to answer sixteen questions if you take the test on a computer. If you take the paper version of the test, you will have twenty-four minutes to answer twenty-five questions. This section tests math concepts that are a little more advanced than the ones in the arithmetic reasoning section, but it involves situations that are less complicated than that section. In other words, you are less likely to see word problems that require you to figure out how to apply the math that you know. Instead, the problems require slightly more advanced concepts.

To give you a sense of the kinds of questions that you will be asked, let's review the three sample questions on the official ASVAB web site. The first one asks you to find the square root of a fraction. The second asks you to find the volume of a rectangular prism, and the third asks you to do a basic algebra problem that involves exponents.

Now let's review the concepts that you will need to know in order to do your best on this section of the test. Just like with the last section, you should work out all of the problems in this section on your own as you work through the guide to get the most out of it.

First, to find the perimeter of an object, you simply add up all of its sides. A rectangle has four sides, and if you add their lengths together, you will have found the perimeter of the rectangle. A hexagon has six sides; you add the lengths of each of those six sides together to get the perimeter of a hexagon. Think about this sample problem:

What is the perimeter of an octagon whose sides are each nine inches long?

An octagon has eight sides. If each side is nine inches long, we can multiply nine times eight to find the perimeter. Nine times eight equals seventy-two, so the answer is seventy-two inches.

Let's try one more sample problem: if a rectangle has a length of twelve and a width of ten, what is its perimeter? To find the perimeter of a rectangle, we simply add up all of the lengths of its sides. In this case, that would be twelve plus twelve plus ten plus ten. As you might have noticed, we could also approach this by multiplying each side times two and then adding those products together. So, we could think of this problem as twelve times two plus ten times two.

Either way, we will get the same answer. You should use whichever approach you find easier to work with. The answer will be forty-four regardless of which approach you use.

Next, let's think about circles. If you draw a line segment from the center of a circle to any point on the edge of the circle, that line segment is called a radius. If you draw a line segment that goes through the midpoint of the circle and touches both sides of the circle, that line is a diameter. Did you notice that a diameter is always twice as long as the radius? This is important to remember, because some problems might require knowing the radius, but the problem will only give you the diameter, or vice versa. But that isn't a problem if you remember that a diameter divided by two equals a radius or a radius times two equals a diameter. The word we use to describe the distance around a circle is "circumference," even though for other shapes we call the distance around the shape the perimeter. In other words, the circumference is the perimeter of a circle. To find the circumference of a circle, you multiply the radius times two and then you multiply that times pi. You can use three point one four as an approximate value for pi. Let's try a practice problem:

What is the circumference of a circle whose radius is equal to five?

We can plug the value of the radius in the problem into the formula for the circumference of a circle. This will give us this formula: circumference equals two times three point one four times five. The result is thirty-one point four.

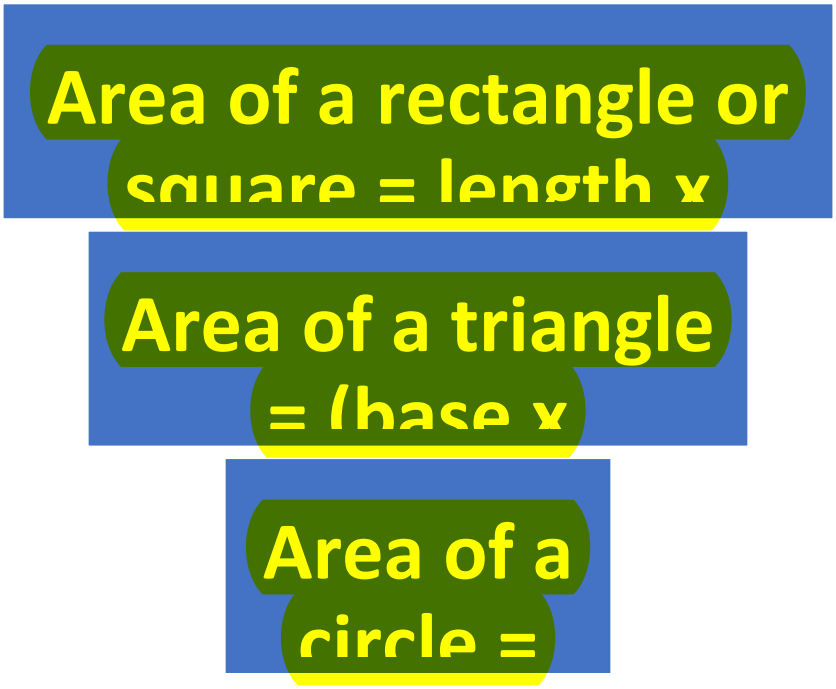
Let's try one more practice problem:

What is the circumference of a circle whose diameter is equal to twelve?

Did you notice that this problem provided you with the diameter and not the radius? Since our formula is that the circumference equals two times the radius times pi, we can replace the "two times the radius" part of the formula with the value for the diameter, since the diameter is always two times the radius. Our formula now reads twelve times pi equals the circumference. Twelve times pi equals thirty-seven point sixty-eight, so that is the solution to the problem.

Next, let's review finding the area of common shapes. To find the area of a rectangle or a square, you multiply the length times the width. To find the area of a triangle, you multiply the base times the height and then you divide that by two. To find the area of a circle, you multiply pi times the radius squared. You can use three point one four as an estimation for pi, just like we did when we were finding the circumference. Figure Ten summarizes these formulas for you:

FIGURE TEN: AREA FORMULAS



Let's try a few sample problems.

If a triangle has an area of six inches squared and a base of three inches, what is its height?

We can plug the values in this question into the formula for the area of a triangle in order to find the missing information, which is the height of a triangle. The formula for the area of a triangle is base times height, divided by two. So we can set this problem up as three times h, divided by two, equals six. Our goal is to get the variable h alone on one side of the equation.

To do that, we begin by multiplying both sides by two. Our equation now reads three times h equals twelve. Next, we divide both sides by three. We have h equals four. And that is the answer to this problem: the height of the triangle is four inches. We can check our work by plugging the base and height into the formula for the area of a triangle. When we do that, we have three times four equals twelve. Twelve divided by two equals six. So we know that we have the correct answer.

Here's another sample problem: What is the area of a circle with a radius of ten meters?

To solve this problem, we plug in the information given in the problem into the formula for the area of a circle. That formula is area equals pi times the radius squared. So we will have area equals pi times ten squared. Ten squared equals one hundred, since ten times ten equals one hundred. Now we will substitute three point fourteen for pi, and our equation will read area equals three point fourteen times one hundred. That equals three hundred and fourteen, so our answer is three hundred and fourteen meters squared.

Here is one final sample problem: If the area of a rectangle is one hundred square feet, and one side of the rectangle is equal to twenty feet, what is the length of the other side of the rectangle?

Since we know that the formula for the area of a rectangle is area equals length times width, we can begin with that. Let's pause in the middle of this particular problem to make a larger point: one mistake that test takers often make on math problems is to try to do too many steps of the problem in their head, without writing down what they are doing. But there are several reasons why it is better to write down more steps of the problem as opposed to fewer steps. The first is that you are less likely to make a math error if the numbers are written down. The second is that it is easier to follow your train of through, especially if you need to come back to the problem, or to part of the problem, later. Remember that your score on the ASVAB depends on your answers to the questions, not on what you had to jot down on the scratch paper, so no one will think less of you or give you a lower score if, for example, you had to write down twelve plus eighteen in order to figure out the sum. If you have any uncertainty at all about

what you are doing, it is better to write it down than to try to do it in your head. Also, writing down a problem can help you figure out how to set it up. And sometimes it helps to draw a picture.

So let's talk about two different strategies for this area problem that can help you to solve it. Both involve writing something down on the scratch paper that can help you. The first approach is to write down the formula for the area of a rectangle. You could write down "A" equals "L" times "W." Then, you can write beneath that the formula with the data from the problem plugged in. The problem tells you that the area is one hundred and one side is twenty. So you can re-write the formula as one hundred equals twenty times W. In this formula, it does not matter which side you call "L" and which you call "W." If you were not sure how to approach the problem, seeing that equation written should get you started. If you are not entirely comfortable with algebra, you can think through the problem step-by-step. You begin by asking yourself, "What was done to the variable?" In this case, the variable was multiplied by twenty. The next question is, "How do I undo what was done to the variable?" You undo multiplication with division. This means that you want to divide both sides of the equation by twenty. When you do that, you end up with five equals W. So, you have the answer to the problem: the other side of the rectangle is five feet long.

Now, let's rework this problem using another strategy. This time, we are going to draw a picture. Since the problem tells us that this is a rectangle, we begin by drawing a picture of a rectangle. Since the problem tells us that the area of the rectangle is one hundred, we can write the number one hundred in the middle of the rectangle or outside of it. Then, the problem tells us that one side of the rectangle is twenty feet long, so we can label that. If you didn't remember the formula for finding the area of a rectangle, you can think to yourself at this point: if one side is twenty feet long, how many rows of twenty squares would I need to add up to a total of one hundred squares? You probably do not actually want to draw in all of these squares because it would take too long, but you can visualize it. And you can probably figure out pretty easily that it would require five rows of twenty squares in order to have a total of

one hundred squares. In this way, you are able to use a picture to help you to solve the problem, even if you are unsure about the formula to use.

To review the general principles we saw in this sample problem, remember that you should try to write a formula or draw a picture if you get stuck on a math problem. Usually, this process will help you to figure out a method to solve the problem, even if there are some gaps in your knowledge. Of course, you don't want to waste time writing or drawing things that you don't need, since this is a timed test, so don't write or draw things just for the sake of doing it, but only do so when it is likely to help you solve a problem.

Next, let's review some of the foundational concepts of geometry. You probably know what a line is, but in geometry, a line has to be perfectly straight and it extends forever in both directions. This is symbolized by little arrows at each end when we draw the line. Of course, we can't draw a line that goes on forever—that's why we put the arrows to indicate that the line is infinite. A line segment is straight, but it had end points, and these are shown with little dots on the end. A ray is like a cross between a line and a line segment: it has one endpoint, but it extends forever on the other end. So when it is represented, one end has a dot for an endpoint, and the other end has an arrow. If two lines or line segments or rays cross each other, we say that they intersect. If they never cross each other, we say that they are parallel. If they cross each other in a way that forms a right angle—that means a ninety-degree angle, like you find in a square--then we say that they are perpendicular.

If two rays share an endpoint, we can say that they form an angle. You might not think of an angle that way, but an angle is really just two rays with one endpoint. If the angle is less than ninety degrees, we call that an acute angle. If it is exactly ninety degrees, that is considered a right angle. If an angle is larger than ninety degrees, it is called an obtuse angle. To help you remember this, you can think of an acute angle as being a "cute" angle because it is little.

Let's try four sample problems.

One. Two rays share an endpoint. The distance between the rays is forty degrees. What kind of angle is this?

The answer is that this is an acute angle. Any angle that is less than ninety degrees is an acute angle.

Two. The interior corners of a rectangle are angles. What is the sum of these angles, and what kind of angles are they?

By definition, a rectangle's sides are perpendicular, so the angles would be ninety degrees each. Since there are four of these angles, we can multiply four times ninety and determine that the sum total of the angles is three hundred and sixty degrees. This is the kind of problem where it can be very helpful to draw a picture if one is not provided for you on the test. This would help you visualize the size and the number of angles and ensure that when you multiplied ninety times four that you did not make any careless mistakes.

Three. Two parallel lines are intersected by a third line. Can a triangle be formed from these three lines?

This is definitely an example of a problem where you should draw a picture. You would begin by drawing two parallel lines. Remember that lines are parallel if they never intersect. Then, draw a third line that intersects the first two lines. Now, the problem did not specify at what angle this third line would intersect the first two lines. In situations like this, it can be a good idea to actually draw multiple drawings, showing that third line intersecting the first two lines at several different angles. When you do this, you will see that there is no way to form a triangle from these three lines, since two of the lines are parallel. So the answer to this question is no, you will not be able to form a triangle. Of course, if the problem did not require that the first two lines were parallel, then it is possible that the third line would have formed a triangle.

Four. You see a drawing of a straight line that has a dot on one end and an arrow on the other. What is the term for this figure?

The answer is that this is a ray. Remember that a ray is a cross between a line and a line segment. A line goes on forever in both directions, while a line segment has two end points, but a ray has one endpoint and goes forever in the opposite direction.

Next, let's think about some basic shapes. You should know that a triangle has three sides. There are three kinds of triangle: an equilateral triangle has sides that are all the same length. Do you hear the word "equal" in "equilateral"? That will help you remember this triangle's name. An isosceles triangle has two equal sides and two equal angles. A scalene triangle has three sides of different lengths, which means that its angles are different lengths.

A quadrilateral has four sides. Here are the main kinds of quadrilaterals:

A square has four sides that are all the same length and four right angles.

A rectangle has four right angles.

A rhombus has four sides that are the same length, but it doesn't have to have four right angles like a square does. If you imagine someone pushing on a square so that its angles change, then you have a rhombus.

A parallelogram has four sides, but they don't have to be the same length and it doesn't have to have right angles. If you imagine someone pushing on a rectangle so that its angles change, then you have a parallelogram.

Keep in mind that some shapes will fit into more than one category. For example, all squares are parallelograms, but not all parallelograms are squares.

Let's try three practice problems.

1. **If you had a square and you tilted it so that it no longer had right angles, what would it be called?**

   Answer: The answer is that it would be a rhombus. A rhombus has to have four sides that are the same length, but it does not need to have right angles.

2. **True or false: All squares are rhombuses.**

   Answer: this statement is true. A rhombus' sides need to be the same length, but its angles can be of any measurement. Since a square has sides of the same length, it meets the definition of a rhombus.

3. **The interior angles of a triangle have the measurements of ninety degrees, fifty degrees, and forty degrees. What is the name for this kind of triangle?**

   Answer: This is a right triangle. The definition of a right triangle is that it has one right angle, which means a ninety-degree angle. That is true of this triangle. We can also consider it scalene, since no two of the angles are the same measurement. A right triangle can be scalene or isosceles.

This concludes our review of geometry. Next, let's look at some more advanced math concepts that you might see on the ASVAB.

Let's review the idea of a least common multiple and a greatest common factor. Sometimes people get these confused because the terms sound similar and because the least common multiple involves finding a number that is larger than the numbers you start with, while the greatest common factor involves finding a number that is smaller than the numbers you start with. So you can see why this is confusing. Let's work through some samples in order to understand how this all works. Consider this question:

What is the least common multiple of three and five?

What this question is asking is what is a number that meets all of these requirements: it is a multiple of three, it is a multiple of five, and it is the smallest number that is both a multiple of three and of five. In order to solve it, begin by listing the multiples of three in order. You should write down six, nine, twelve, fifteen, eighteen, and twenty-one. Now make a list of the multiples of five. These are five, ten, fifteen, twenty, and twenty-five. Now compare your lists. What is the smallest number that appears on both lists? It is fifteen. This means that fifteen is the least common multiple of three and five. The reason it is called the "least" is because of all

of the multiples and three and fifteen have in common, it is the smallest. It is called “common” because it is a multiple of both three and of fifteen. And it is a multiple because it is the result of multiplying the three or the five by another number. That’s why we call it the least common multiple. Notice that the least common multiple is always larger than or equal to the numbers that it is the least common multiple of. So do not be confused by this. Let’s try one more example:

What is the least common multiple of four and six?

Begin by listing the multiples of four: eight, twelve, sixteen, twenty, twenty-four, twenty-eight. Now list the multiples of six: twelve, eighteen, twenty-four. The smallest number that is on both of those lists is twelve, which means that twelve is the least common multiple of four and six.

Now, let’s review the idea of the greatest common factor. The factors of a number are the numbers that you can multiply together to get that number. So let’s think about the number ten. What numbers can you multiply together to get ten? You can multiply ten and one. You can multiply two and five. This means that one, two, five, and ten are the factors of ten. Now that we know what a factor is, let’s think about the greatest common factor. The greatest common factor refers to the largest number that is a factor for two other numbers. Think about this sample problem:

What is the greatest common factor of twelve and sixteen?

To solve this, we begin by listing all of the factors of twelve. They are one, two, three, four, six, and twelve. Next, we list all of the factors of sixteen. They are one, two, four, eight, and sixteen. Now, we look for the largest number that is on both lists. That is four, which means that four is the greatest common factor of twelve and sixteen. Did you notice that the greatest common factor will always be smaller than or equal to the numbers that is the factor of?

Let's try one more sample problem. What is the greatest common factor of forty and one hundred?

To solve this, begin by listing the factors of one hundred. They are one, two, four, five, ten, twenty, twenty-five, fifty, and one hundred. Let's pause this problem for a minute to make a general observation about finding the factors of a number. You can make that task a little bit easier if you notice that a factor can never be more than half of the number. Think about why this is so: you may be able to multiply two by half of your number, in which case two and half of the number will be factors. And you can multiply one times the number itself. But there is no number that you can multiply by more than half of a number in order to get the number. So, there will be no factors of a number that are greater than half of the number. That means that in this problem, once we have made it to fifty, we can stop looking for factors of one hundred because there aren't any more. This can make the process easier. Now that we have our factors of one hundred, let's think about the factors of forty. Again, remember, we don't need to test anything greater than twenty because factors can't be greater than half of the number except, of course, for the number itself. The factors of forty are one, two, four, five, eight, ten, twenty, and forty. Now that we have our lists, we need to compare them and identify the largest number that is on both lists. That is twenty, so we know that twenty is the greatest common factor of forty and one hundred.

Next, let's review roots and exponents. An exponent is a quick way to do repeated multiplication. It is represented as a small number placed to the right of another number. Think about the expression four to the second power. We would write that as a regular-sized four with a small number two just to the top right of the four. It means that we multiply four times itself two times. If we had four to the fifth power, that would mean that we multiply four by itself five times. That is how exponents work. The opposite operation of an exponent is a root. We usually talk about square roots, but you can also have cube roots or fourth roots, although these are less common. Think about this sample problem:

What is the square root of thirty-six?

Here is what that problem is asking: what number can you multiply by itself to get thirty-six? If you multiply six times six, the result is thirty-six, so that means that the square root of thirty-six is six.

Let's try another sample problem:

What is three to the fourth power?

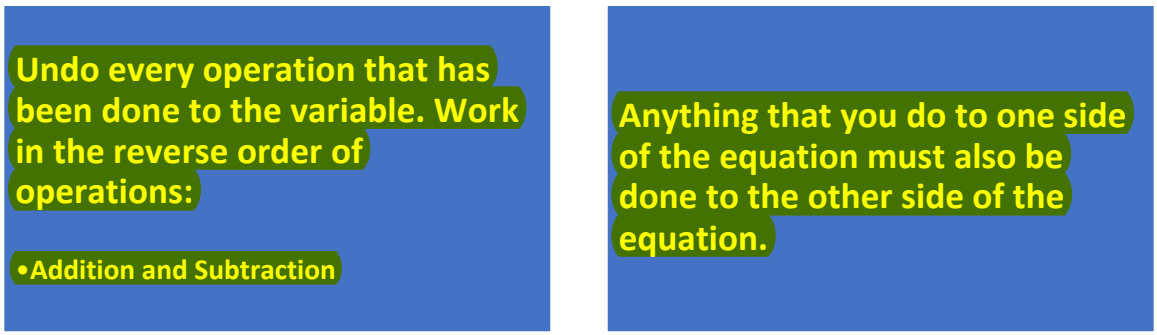
This problem is another way of asking what is three times three times three times three? The answer to that is eighty-one, so three to the fourth power is equal to eighty-one.

Finally, let's review the basic concepts of algebra because you will probably see some simple algebra problems on the ASVAB. When you see a letter, such as "x" or "y," in a math problem, that means that that it is a variable. A variable represents some other number, but we don't know what it is. Anything that you can do to a regular number, you can do to a variable. So you might see an expression that reads x squared minus 2 equals twenty-three. We don't know what the x equals, but we can solve for it. There are two main rules to remember when doing algebra. Here is the first rule: to solve for a variable, you have to undo everything that was done to it. In our example, the variable x was squared and then two was subtracted from it. To solve for x, we undo what has been done to it. We have to go in the reverse order of operations, since we are undoing what was done to x. So, since two is subtracted from X, we have to add two to it. This brings us to the second basic rule of algebra: whatever you do to one side of an equation, you have to do to the other side. If you didn't, it wouldn't be equal anymore. Because this is an equation and because we want to keep the two sides of the equation equal, we have to follow the rule that if we do some mathematical operation to one side of the equation, we also have to do it to the other side of the equation. So, if we want to add two to one side of the equation, we can do that, but it means that we also have to add two to the other side of the equation so that the sides are still equal to each other. When we add two to both sides of the equation, we will have x squared equals twenty-five. Now, we need to undo squaring x. Remember that taking the square root undoes squaring something, so we will find the square

root of both sides of the equation. This will give us x equals five. We have solved for x. The nice thing about algebra problems is that it is easy to check your work. You can do the problem plugging in five for the x and see if the equation is true. Let's do that now. Five squared equals twenty-five, and twenty-five minus two equals twenty-three. So, we can be confident that we have solved the equation correctly.

Since it is such an important idea, let's go over it one more time: the two basic rules of algebra are that you undo everything that has been done to the variable, and whatever you do to one side of the equation, you have to do to the other. See Figure Eleven, which summarizes how this works:

FIGURE ELEVEN: HOW TO APPROACH ALGEBRA PROBLEMS



Let's do three more algebra sample problems.

1. **Given the equation four times A plus eight equals forty, solve for A.**

Before we begin this problem, notice that our variable can be any letter of the alphabet. It doesn't matter if it is X or Y or A or B. In this problem, we have multiplied A times four and then added eight to it. This has given us the result of forty. To solve this problem, we need to undo everything that has been done to A. Remember that we need to go in the reverse order of operations, since we are undoing what was done to A. Notice that eight was added to A. We can undo addition through subtraction. So, let's subtract eight from both sides of the equation. Remember that anything that we do to one side of the equation we have to do to the other

side. Once we subtract eight from both sides, we will have four times A equals thirty-two. Now we see that A has been multiplied by four. We are able to undo multiplying by four by dividing by four. And, again, we have to do that to both sides of the equation. When we do that, we have A equals eight. Remember that we can always check our work on an algebra problem by plugging in our answer into the equation and being sure that the sides of the equation really are equal. If you have time, you should definitely do this because this process will let you know for sure if you have gotten the correct answer to the question. Our answer was that A is equal to eight, so let's plug the value of eight into the equation where the variable A was. That gives us four times eight plus eight equals forty. When we work that out, we see that it is in fact true, since four times eight equals thirty-two and thirty-two plus eight equals forty. So we can be confident that we have gotten the correct answer to this question.

2. **Given the equation X squared over three plus five equals eight, solve for X.**

Remember that no matter what is in the equation, our basic process is the same two steps: we undo everything that has been done to the variable, and whatever we have done to one side of the equation we have to do to the other side. In this case, we have added five to one side of the equation. We can undo that by subtracting five, but of course we have to do that to both sides of the equation. When we do that, we end up with X squared over three equals three. Remember that a fraction is just another way of expressing division, so X squared over three is precisely the same as X squared divided by three. We'll need to undo that division. We undo division with multiplication. This means that we need to multiply both sides of the equation by three. When we do that, we have X squared equals nine. Remember that X squared is another way of saying "X times X." In fact, you could write that out as a step in your equation if you found that helpful. Another way to solve this would be to take the square root of each side, since roots are the opposite of exponents. To approach that problem in this way, you would be asking what number you need to multiply by itself in order to equal nine. You should be able to see that the answer is three, so X is equal to three. Once again, we can check our work by plugging three into the equation and verifying that the equation is true. Let's do that now. Three squared is the same as three times three, which equals nine. Nine divided by three equals

three, and three plus five equals eight, so our equation is true and we can be confident that we have found the correct answer.

3. Given the equation twelve plus four times Y equals fifty-two, solve for Y.

We will, as usual, follow our two rules of undoing what was done to the variable and doing the same thing to both sides of the equation in order to solve this problem. Since twelve was added to one side of the equation, we will begin by subtracting twelve from both sides of the equation. This results in four times Y equals forty. Now, since Y has been multiplied by four, we will undo that by dividing both sides of the equation by four. When we do that, we end up with Y equals ten. That is the correct answer to this problem. Let's test it by substituting ten for Y and seeing if the equation is true. Ten times four equals forty, and forty plus twelve equals fifty-two, so our equation checks out and we know that we have found the correct answer to the problem.

This concludes our review for the mathematics knowledge section.

Key Take-Aways

One. To find the perimeter of an object, you simply add up all of its sides.

Two. To find the circumference of a circle, you multiply the radius times two and then you multiply that times pi.

Three. To find the area of a rectangle or a square, you multiply the length times the width. To find the area of a triangle, you multiply the base times the height and then you divide that by two. To find the area of a circle, you multiply pi times the radius squared.

Four. A line is straight, and it extends forever in both directions. A line segment is straight, but it has end points. A ray has one endpoint, but it extends forever on the other end.

Five. If two lines or line segments or rays cross each other, we say that they intersect. If they never cross each other, we say that they are parallel. If they cross each other in a way that forms a right angle, then we say that they are perpendicular.

Six. If an angle is less than ninety degrees, it is an acute angle. If it is exactly ninety degrees, it is a right angle. If an angle is larger than ninety degrees, it is an obtuse angle.

Seven. An equilateral triangle has sides that are all the same length. An isosceles triangle has two equal sides and two equal angles. A scalene triangle has three sides of different lengths, which means that its angles are different lengths.

Eight: A quadrilateral has four sides. The quadrilaterals include squares, rectangles, rhombuses, and parallelograms.

Nine. The least common multiple of two numbers is the smallest number that is a multiple of both of the numbers.

Ten. The greatest common factor of two numbers is the largest number that is a factor of both of the numbers.

Eleven. An exponent is a quick way to do repeated multiplication. The opposite is a root.

Twelve. The two basic rules of algebra are that you undo everything that has been done to the variable, and whatever you do to one side of the equation, you have to do to the other.

QUIZ

1. Given the equation three x squared plus six equals thirty-three, solve for x.

A. the square root of five

B. the square root of thirteen

C. three

D. five

Answer: C. To solve this problem, begin by subtracting six from each side. That gives you three x squared equals twenty-seven. Next, divide each side by three. Now you have x squared equals nine. Finally, take the square root of each side. Now you have x equals three. If you chose any of the other answers, you may have done the operations out of order. Remember that in an algebra problem, you are undoing what has been done to the variable, so you have to use the order of operations in reverse.

2. What is the area of a triangle if the base is two feet and the height is four feet?

A. two

B. four

C. eight

D. sixteen

Answer: B. To solve this problem, we need to use the formula for the area of a triangle and plug in the numbers from the problem. The formula is base times height divided by two, so we will have two times four divided by two. Two times four is eight and eight divided by two is four, so the answer is four feet.

3. What is the least common multiple of six and five?

A. one

B. five

C. six

D. thirty

Answer: D. To solve this problem, begin by making a list of the multiples of five, which are ten, fifteen, twenty, twenty-five, thirty, thirty-five, and forty. Then, make a list of the multiples of six. These are twelve, eighteen, twenty-four, thirty, and thirty-six. Now, we need to find the smallest number that is on both lists. That number is thirty, so thirty is the least common multiple of five and six.

4. **Which term describes two rays that share an endpoint?**

A. parallel

B. perpendicular

C. angle

D. triangle

Answer: C. The definition of an angle is two rays that share an endpoint, so option C is the correct answer.

5. **Which term describes two lines that intersect at a ninety-degree angle?**

A. parallel

B. perpendicular

C. obtuse

D. acute

Answer: B. The definition of perpendicular is two lines that intersect at a ninety-degree angle.

6. **The sides of a triangle measure three, four, and five inches. Which term describes this triangle?**

A. perpendicular

B. equilateral

C. isosceles

D. scalene

Answer: D. The definition of a scalene triangle is that all three of its sides are different lengths.

7. Given the equation open parentheses, open parentheses, x over four, close parentheses, minus 2, close parentheses, times six equals six, solve for x.

A. zero

B. one

C. six

D. twelve

Answer: D. To solve this problem, you undo everything that has been done to the x. Remember to use the order of operations, but in reverse. So, first, divide each side by six. This will give you open parentheses, x over four, close parentheses, minus 2 equals one. Next, add two to both sides. This will give you x over four equals three. Next, multiply both sides by four. This results in x equals twelve.

8. Which of the following is true of a parallelogram?

A. it must have four sides

B. it must have ninety-degree angles

C. it must have sides that are all the same length

D. it must be longer than it is tall

Answer: A. A parallelogram must have four sides, but none of the other options have to be true for a shape to be a parallelogram.

9. What is five to the third power?

A. five

B. fifteen

C. twenty-five

D. one hundred and twenty-five

Answer: D. To solve this, you multiply five times itself three times. So, you would have five times five times five. Five times five is twenty-five, and twenty-five times five is one hundred and twenty-five.

10. Given the equation four times x squared minus two equals three hundred and ninety-eight, solve for x.

A. one

B. five

C. eight

D. ten

Answer: D. To begin, add two to each side. Then the equation reads four x squared equals four hundred. Then, divide each side by four. Now the equation is x squared equals one hundred. Next, take the square root of each side. Now the equation reads x equals ten.

WORD KNOWLEDGE (WK)

The word knowledge section of the ASVAB will have sixteen questions to answer in eight minutes if you take the test on a computer. If you take the paper version, you will have eleven minutes to answer thirty-five questions.

You will not be surprised to hear that this section tests your knowledge of words. In other words, it is a vocabulary test. The questions might be in one of two formats. One kind of question will provide you with a word and then ask you which of the answer choices means most nearly the same thing. The other kind of question will not really look like a question: it will just be a sentence with one word highlighted. Your task is to choose the answer option that means about the same thing as the highlighted word. As you can see, even though the two kinds of formats are somewhat different, they both ask you to do the same thing, which is to select an answer choice that means the same as the word in the question. The technical term for two words that mean the same thing is a synonym. You don't necessarily need to know the word "synonym" for the ASVAB, but the idea is important: you are always looking for two words whose meanings are about the same. Some test-takers get tripped up and try to look for words with opposite meanings, or words that rhyme, or words that begin with the same letter, or words that overall sound the same. But the ASVAB is looking for something very specific: it is looking for words with the same meaning. Do not be thrown off by words that have something else in common. You need to focus on the meaning of the words.

To give you a sense of the level of difficulty for this test, the three words tested in the official sample questions online are the words antagonize, wilted, and apprehension. So they are words that you might not use in everyday conversation, but they aren't technical jargon that only experts in certain fields know. They are the kinds of sophisticated words that you might find in a reading assignment for a college course.

Let's review some ways that you can prepare for this test. First, you should read as much as you can. And the materials that you select to read have to be in what we call the "sweet spot." That means that they aren't too easy or too hard. If you select reading materials that are too easy, they aren't likely to improve your vocabulary because you will already know all of the words in them. This means that books that are classified as young adult literature or most popular

websites are not likely to help you expand your vocabulary. On the other hand, if you select materials that are too difficult—like an article in a journal written for medical doctors—it is likely that there will be so many words and concepts in it that you do not know that you won't be able to comprehend it, and it won't end up helping you expand your vocabulary because you won't be able to follow the ideas in what you are reading. So what you want to look for are materials that are just a bit challenging for you. This means that there might be just one new word per paragraph. In that situation, you can usually figure out what the words means from the way that it is used. If you are looking for reading material, a good place to look is the website called The Conversation. It contains articles on a variety of topics, usually written by college professors, but written to be read by a general audience, not by other college professors.

One other thing that you should know about expanding your vocabulary by reading is that it is not going to happen overnight. Research shows that you need to read a new word about a dozen times before you are able to understand the definition. And this doesn't mean that you read one sentence with the word in it twelve times in a row. Rather, it means that you see the word in twelve different sentences. This allows your brain to figure out what the word means and what it doesn't mean. This is an important part of the process. It is why simply studying lists of words is not likely to be helpful to you, because you need to see how the word is actually used in order to really understand it. This is why reading is the best way to increase your vocabulary. And you can't "cram." Rather, try to read a little bit each day.

Second, you can improve your vocabulary by studying Greek and Latin roots. Most words are made out of smaller parts, and we call these parts roots. Because Greek and Latin contributed a lot of words to English, you can often use Greek and Latin roots to figure out the meaning of a word that you don't know. For example, let's say that you didn't know the meaning of the word "television," but you knew that the Greek root "tele" meant "far" and the Latin "visio" meant "sight." You would be able to determine that the word "television" had something to do with seeing things that were far away. This is actually a pretty good basic definition of what a television is. The great thing about learning Greek and Latin roots is that learning one root can

help you understand dozens of English words because one root will appear in many English words. For example, you can find the root “tele” in the English words telephone, telescope, telegraph, telegram, telekinesis, telecardiology, telemarketer, telemetry, telecaster, and teleport. Study the following three charts so that you are familiar with the most common Greek and Latin roots. You may find it helpful to make flashcards of these words so that you can practice them. If you are going to practice with flashcards, here is how to do it. Look at one side of the flashcard. Ask yourself, “Do I know the meaning of this word?” Say the meaning to yourself. Then, turn the flashcard over. If you got the word right, put it in one pile. If you got it wrong, put it back in the pile of cards to study. This way, you keep reviewing the ones that you do not know until you can get them right. This is the most efficient way to study with flashcards. Figures Twelve, Thirteen, and Fourteen contain lists of the most commonly used Greek and Latin roots in English.

Figure Twelve: Greek Roots

Root	Meaning	English Words
Anthro	Human	Anthropology, Misanthrope
Auto	Self	Autobiography, Automatic
Bio	Life	Biology, Biography
Chron	Time	Chronological, Anachronism
Dyna	Power	Dynamite, Dynasty
Dys	Bad	Dystopia, Dysfunction
Gram	Written	Monogram, Epigram
Hydr	Water	Hydration, Hydrant
Hypo	Below	Hypothermia, Hypocritical
Logy	Study of	Geology, Anthropology
Meter	Measure	Perimeter, Kilometer
Micro	Small	Microbe, Microscope
Mono	One	Monogamy, Monologue
Morph	Shape	Anthropomorphic, Amorphous
Nym	Name	Synonym, Anonymous
Phil	Love	Philosophy, Anglophile
Phon	Sound	Symphony, Cacophony
Therm	Heat	Thermometer, Thermodynamics

Figure Thirteen: Latin Roots

Root	Meaning	English Words
Ambi	Both	Ambidextrous, Ambiguous
Aqua	Water	Aquatic, Aquarium
Aud	To hear	Auditory, Auditorium
Bene	Good	Benefactor, Benevolent
Cent	100	Century, Percentage
Circum	Around	Circumference, Circumnavigate
Contra	Against	Contradict, Contraindicate
Dict	To say	Valedictorian, Dictator
Duc	To lead	Aqueduct, Abduct
Fac	To make	Artifact, Manufacture
Form	Shape	Malformed, Transform
Fort	Strength	Fortify, Fortitude
Fract	To break	Refract, Fracture
Ject	To throw	Interject, Projectile
Jud	To judge	Adjudicate, Judicial
Mal	Bad	Malevolent, Malice
Matr	Mother	Matriarch, Matricide
Port	To carry	Export, Deportment
Spect	To look	Retrospect, Introspection

Figure Fourteen: Prefixes

Root	Meaning	English Words
Anti	Against	Antithesis, Antifreeze
De	Opposite	Devalue, Denounce
Dis	Not	Discover, Discomfit
En	Cause to	Enable, Entice
Fore	Front of	Foreground, Forearm
In	In	Income, Inundate
Im	Not	Immoral, Immutable
Inter	Between	International, Interdict
Mid	Middle	Midday, Middling
Mis	Wrongly	Misspell, Miscalculate
Non	Not	Noninvasive, Nonpartisan
Over	Above	Overeat, Overdose
Pre	Before	Prejudice, Predispose
Re	Again	Reimagine, Remuneration
Semi	Partly	Semiannual, Semiformal
Sub	Under	Submarine, Subterranean
Super	Above	Superscription, Superfluous
Trans	Across	Transcontinental, Transmogrify
Un	Opposite	Unfeasible, Uncouth
Under	Lacking	Underacknowledged, Underappreciate

Notice that these three charts have sample words in English that use the Greek and Latin roots. If you do not know these words, you can make flashcards for them, too. But remember that reading a word in context is the best way to learn it, so focus your study time on reading things that are just a little bit challenging to you. One strategy that many students find effective is to set an alarm on their phone to go off at a certain time each day. When the alarm sounds, they read one article from The Conversation website. You will be impressed at how many words you can learn using this method.

Third, here is a bit of strategy that can help you. Remember that words can have more than one meaning. Think about this sample problem:

Which word means most nearly the same thing as ball?

A. opera
B. dance
C. festival
D. court

Now, if you are like most people, the first thing that comes to mind when you hear the word "ball" is a round object, such as a basketball or a tennis ball. But that isn't the only meaning of the word "ball." A ball is also the name for a dance. This means that option B, dance, was the correct answer to this question. If you read the question and you were thinking of a round object, you were probably very confused by those answer options since none of them have anything to do with that round object. So one important strategy for answering these questions is to think about other possible meanings of the word besides the most obvious meaning. Let's think about two more words that have multiple meanings.

One. Bark. Probably the first thing that comes to mind when you hear the word "bark" is the sound that a dog makes. But if the sentence on the ASVAB is, "The bark was damaged by the increased population of beetles in the forest," then it doesn't make sense to think about the sound that a dog makes. Instead, you need to think about other meanings of the word "bark."

In this sentence, it seems to refer to the covering of a tree. If your answer options are bird, leaf, coating, and water, then coating is the best choice.

Two. Occupation. What comes to mind when you hear the word "occupation"? Do you think about an army occupying a country? Do you think about filling out a form that has the word "occupation" and expects you to list the kind of work that you do? If your answer choices are elevation, profession, incidental, and radial, then the correct choice is profession, since that word means about the same as occupation. It uses the meaning of the word that refers to someone's job.

One thing that you may have noticed from these sample exercises is that the answer choices are not perfectly equal to the word. In our example with the word "bark," the correct answer choice was "covering." But the words "bark" and "covering" don't mean exactly the same thing. Bark only refers to the covering of a tree, not to something that covers something else. That's OK. Some people struggle with these questions because it seems like none of the answer choices mean exactly the same thing as the word in the question, but you don't have to worry about that. They don't have to mean exactly the same thing; they just have to be closer in meaning than any of the other options. The nature of synonyms—remember, that is the term for words that mean the same thing—is that they are not normally perfectly equal to each other. For example, the words "azure" and "cerulean" are synonyms in the sense that both describe a shade of the color blue. But a fashion expert would tell you that azure and cerulean are not exactly the same color. They are still synonyms. So, remember, don't get stressed out if the answer choices don't seem perfect to you. Just look for the one that is closest in meaning to the word in the question.

KEY TAKE-AWAYS

One. Read as much as you can. Focus on readings texts that are just a little bit challenging to you.

Two. Study Greek and Latin roots.

Three. Remember that words can have more than one meaning.

Four. The answer choice needs to be the closest in meaning to the word in the question, but it will not necessarily mean exactly the same thing as the word in the question.

QUIZ

Note: For this quiz, we will repeat at the end of the sentence the word that you are supposed to match.

1. **He has trouble conveying his thoughts when he is upset. Conveying.**

   A. changing

   B. communicating

   C. managing

   D. controlling

   Answer: B. The word "convey" means to transfer or transmit information. So the word with the closest meaning in the answer choices is "communicating." One thing that you might have noticed is that all of the answer options would make sense in the sentence. For example, you could say that someone has trouble changing their thoughts or managing their thoughts or controlling their thoughts when they are upset. But none of these is the correct answer to the question. Remember that you aren't just looking for a word that makes sense in the sentence. Instead, you are looking for a word that means the same thing as the specified word in the sentence.

2. **The dreary landscape was not something that she was expecting. Dreary.**

   A. dull

   B. colorful

   C. jagged

   D. hypnotic

   Answer: A. The word "dreary" refers to something that is gloomy, dull, or depressing. So, the closest meaning of the answer choices is dull. Once again, all of the answer choices would make sense in the sentence, but only option A means about the same thing as the word "dreary," so it is the correct choice.

3. The new car prompted envy in many of his friends. Envy.

A. anger

B. joy

C. jealousy

D. pride

Answer: C. The word “envy” means to be jealous of something, so option C is the best answer.

4. Her attempt to modify the rules was challenged by the other players. Modify.

A. increase

B. eliminate

C. decrease

D. change

Answer: D. The word “modify” means to change something, so option D is the best answer.

5. The plant may perish if he continues to treat it that way. Perish.

A. grow

B. flower

C. die

D. change

Answer: C. The word “perish” means to die, so option C is the best answer.

6. Which word means about the same as the word prohibit?

A. allow

B. increase

C. change

D. ban

Answer: D. The word “prohibit” means to ban, so option D is the best answer.

7. Which word means about the same thing as the word refute?

A. deny

B. support

C. alter

D. manage

Answer: A. The word “refute” means to prove something is wrong, so deny is the best answer.

8. Which word means about the same thing as the word reproach?

A. aid

B. hold

C. criticize

D. harm

Answer: C. The word “reproach” means to criticize, so option C is the best answer.

9. Which word means about the same thing as the word sinister?

A. ample

B. compute

C. evil

D. holy

Answer: C. The word sinister means that something is ominous, evil, or dangerous, so option C is the best answer.

10. Which word means about the same thing as the word surly?

A. helpful

B. unfriendly

C. equal

D. burly

Answer: B. The word “surly” means gruff or unfriendly, so option B is the best answer. You should notice one other thing about this question: did you see that option D, burly, rhymes with the word surly? Sometimes the test makers might use rhyming words or words that begin with the same letters or words that are in some way similar because those answers are attractive to students. But remember that you are always looking for a word that shares the same meaning as the word in the problem, not for words that might be similar in other ways, such as how they sound.

PARAGRAPH COMPREHENSION (PC)

The paragraph comprehension section of the AVAB will have eleven questions to answer in twenty-two minutes if you are taking it on a computer. If you take the paper version, you will have thirteen minutes to answer fifteen questions.

In this section, you will be given a short paragraph to read and then you will be asked to answer questions to show if you understood the paragraph. The paragraphs will be quite short, so you will only have to consider about three sentences in order to answer the question.

In general, the questions are tricky in the sense that they will ask you about material in the paragraph that might not be obvious to you if you are not a careful reader. Let's work through an example so you can get a feel for how this works.

Consider this sample paragraph:

If your memory of slow-cooker meals conjures up gloppy soups and pasty meats, you will be startled by today's slow cooking recipes. The latest generation of recipes usually involves either searing first in a pan or adding crunchy toppings after cooking to avoid the dreaded texture of baby food.

Question: The author is arguing that modern slow-cooked meals are usually:

A. gloppy
B. smooth-textured
C. nutritious
D. varied in texture

The correct answer to that question is option D, varied in texture. It is true that the author does mention gloppy soups, but the point of the paragraph is that modern slow-cooked meals are not like that; only the older ones are like that. Similarly, the author does mention the texture of baby food, which is similar to the second answer option, smooth-textured, but again the author's point is that modern recipes for the slow-cooker are not like this. If you just skimmed the passage and you did not pay attention to what the author was arguing, you might have chosen one of these options because the words and the ideas in them would have been familiar

to you based on what you had read in the passage. But just because the ideas are in the passage does not mean that they apply to the modern meals. In fact, they only apply to the older recipes. So they are incorrect. Now let's think about the third answer option, which was nutritious. Is it true that modern recipes are more nutritious? Maybe. But the important thing to pay attention to here is that the paragraph does not mention nutritional value at all. This is a very important point: you do not want to add ideas to the passage. You need to focus on what is in the passage and not make up your own ideas. In other areas of your life, it is great to be creative and make connections, but it is never a good idea to do that on a reading test. A reading test is testing whether you understood what was in the reading passage, not what else you might know about the topic of the reading passage from other sources. It is also not testing your ability to be creative. You need to stick to what is right in front of you.

Let's try another sample passage:

He hurried around the apartment, hiding pizza boxes under the sink and scooping dirty clothes off of the floor and shoving them into drawers filled with art supplies. He grabbed the vacuum and, more quickly than anyone would have thought possible, pushed it around the room. The fact that the vacuum was not plugged in did not seem to bother him—his goal was to create vacuum marks on the carpet. He had just returned the vacuum to the closet, jumped on to the couch, and opened a magazine when he heard a key in the lock. As his mother walked in, he looked up innocently at her. She did not suspect his trickery.

Question: What does the word "trickery" refer to?

A. his attempts to make the home look clean
B. the fact that he was hiding a friend in the bathroom
C. his knowledge that his mother should not be there
D. the fact that the vacuum was not plugged in

The correct answer is A, his attempts to make the home look clean. Hopefully, you were able to determine that the point of the passage is that the first character wants to make the home look clean without actually putting in the effort to clean it. This is why he puts pizza boxes under the

sink and dirty clothes in the drawers. It is also why he doesn't care if the vacuum is plugged in: it doesn't matter to him whether there is dust on the floor; he just wants to create vacuum marks on the carpet. We can learn something from thinking about the wrong answers to this question, so let's do that now. The first wrong answer is that he was hiding a friend in the bathroom. There is no indication of this in the passage. Once again, this is not the time to be creative and to say to yourself, "Well, maybe he was hiding someone in the bathroom—it's possible." Anything is possible, but the correct answer will always be something that has evidence for it in the passage. If there is no evidence, it cannot be the correct answer. If you are stuck on a question, you can ask yourself, "What evidence would I use to support this answer?" There is nothing in this passage that supports the idea that there was someone in the bathroom. So, it can't be the correct answer. You can also ask yourself, "What would evidence for this idea look like?" In this case, evidence for the idea that there was someone in the bathroom might be like one of these sentences:

One. He peeked in the bathroom and raised him finger to his lips in a shushing gesture.

Two. He carefully shut the door to the bathroom and then slipped a note under it.

Three. He made sure that his mother didn't go near the bathroom.

Any of those sentences could be evidence that someone was in the bathroom. But, as it was written, the passage does not have any evidence that would lead you to the conclusion that someone was in the bathroom.

Now, let's look at another wrong answer option. It is, "the fact that the vacuum was not plugged in." Now, this is a somewhat reasonable answer because it is true that he pushed the vacuum around without plugging it in. But this is not the best answer. The part about the vacuum is only part of the trickery. But the trickery also refers to what he did to the pizza boxes and the dirty clothes. So that means this is an answer that is partially correct, but not entirely correct. You should always look for the most correct answer. Part of that process is reading all of your answer choices to be sure that you have chosen the correct answer. Sometimes, test takers get something wrong because they choose an answer that is partially correct without

reading all of the answer choices, and it turns out that one of the other answers was even better. So, again, be sure to read all of the answer options.

Now that we have worked through these two sample paragraphs, you should have a better idea of what to expect on this section. In general, the questions will require you to read the paragraph closely. You are likely to get the wrong answer if you choose an answer choice just because it has words or ideas in it that were mentioned in the paragraph. That isn't enough for an answer to be correct. Rather, the correct answer has to correctly represent the author's ideas. The correct answer may or may not repeat the actual words of the passage. So, there are two principles you should take from this. First, an answer that uses words from the passage is not necessarily correct. And, second, an answer that does not use the same words as were in the passage is not necessarily wrong.

Let's review some more reading strategies that can be helpful.

One. Think about the structure of the text. This will help you follow the argument that the author is making. Normally, a text will have one of these five structures.

First, compare or contrast. In this structure, two or more things are compared. Think about this sample paragraph:

Algebra usually involves finding the value of a variable, while geometry focuses on the properties of shapes. Of course, variable can be used in problems involving shapes, but these two branches of math usually differ in this way. In most schools, a first year of algebra is taught and then geometry is taught.

In this paragraph, algebra and geometry are compared. So, the structure of this paragraph is the compare or contrast structure.

Second, sequence. When a text tells you about something in order, it has a text structure that is called a sequence. Think about this sample paragraph:

To paint a bedroom, start by removing all of the furniture. Then, tape any areas that you do not want to paint. Cover the floor to protect it. Begin by applying a coat of primer. Once the primer has dried, cover it with one coat of paint.

In this paragraph, the writer tells you what to do and tells you the order in which to do it. This means that the structure of this paragraph is a sequence.

Third, cause and effect. If a paragraph describes something that causes something else to happen, we call that a cause and effect structure. Think about this sample paragraph:

What happens when parents read a lot to their children? There are exhaustive studies that show many benefits to this practice. Children who are frequently read to have better vocabularies, which helps them do better in school. They also have more knowledge about the world in general, which also impacts their school performance. And, they develop empathy for other people based on their exposure to stories.

Did you notice the cause and effect described in that paragraph? The cause is parents reading to their children. And the effects are improved school performance and increased empathy.

Fourth, problem and solution. In this text structure, the author presents a problem and then describes the solution. Consider this sample paragraph:

Each year, over ten thousand Americans are killed in car accidents caused by drivers who are texting. But the tragedy of these deaths cannot be captured in raw numbers. Each one of these incidents involves lost potential and value. But there is a compelling solution: new technology would make it impossible for a phone to function when a car is in motion. If states were to require this technology, deaths from texting while driving would plummet.

Were you able to find the problem and solution in that paragraph? The problem is the number of people who die because a driver was texting and driving, and the solution was adopting new technology.

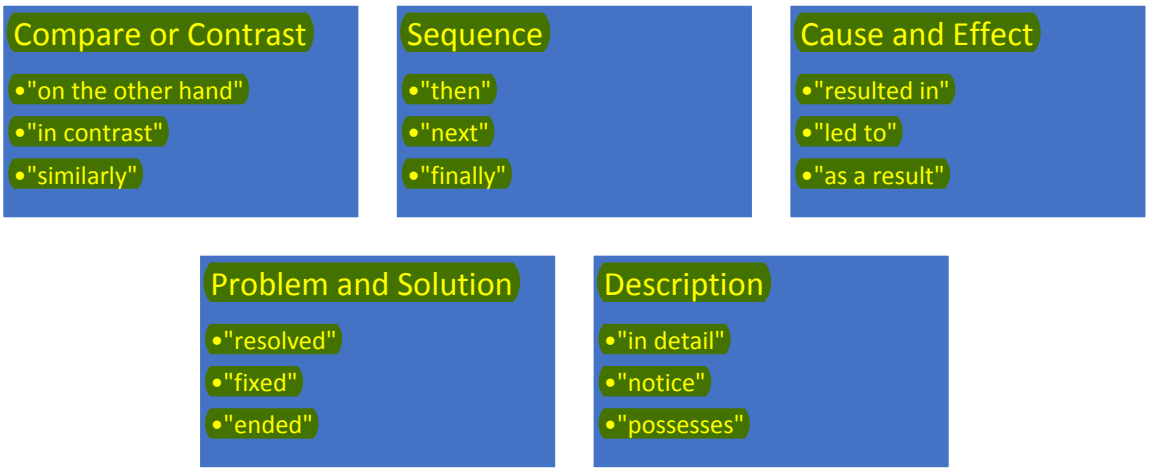
Fifth, description. A text with a description structure means that the author is describing something. Consider this paragraph:

The Alaskan malamute is a lovely dog. They can grow to be very large, but they maintain their sweet temperament. They are good with children, and they have lush black and white coats. They are explorers, and they may return from their walks with gifts for their owners in the form of shells, plants, or small animals.

In this passage, a certain breed of dog is described. So the text structure is a description.

Now, the questions on the ASVAB are not going to ask you to name the type of text structure used in a paragraph. That is not why it is important to know the text types. Rather, the point of thinking about the text structure type is that recognizing the structure will help you to better understand the text. You will be better able to follow the author's train of thought if you understand the structure of the text. A comparison can help you understand this point. Usually, when you go to the movies, you know if you are going to see a mystery, horror, sci fi, or romance movie. And knowing that helps you to interpret the movie and know what to expect. You don't expect the same thing to happen in a horror movie when a guy and a girl sit down on a couch to chat as you would expect in a romantic movie! Similarly, knowing the text structure can give you a better understanding of what is likely to happen in a passage that you read. Figure Fifteen summarizes the five main text structures; it also includes the kinds of words that may be used to signal that kind of text structure:

Figure Fifteen: Text Structures



Now that we have reviewed text structures, let's consider a few other reading strategies.

Two. Your reading speed should be somewhere between skimming and memorizing. You may not have thought about it like this before, but there are different kinds of reading. You might scroll through a news article on your phone, just barely reading it, skimming it only to get the gist. That's one kind of reading. On the other hand, you might read a math textbook in such a way that you are practically memorizing the material. Memorization is the other extreme from skimming. But neither skimming nor memorizing is a good strategy for reading on the ASVAB. Instead, you want to be somewhere in the middle. The problem with trying to memorize is that it requires you to read really slowly. This makes it likely that you will run out of time. And there is simply no need for it since you can always return to what you were reading. There will be questions that ask you to identify details from the reading passage, but you can always return to the passage to check on the details. So there is no need to try to memorize what you are reading. On the other hand, don't just skim the passage. If you do that, you will miss too many important aspects of the passage, such as its structure. Instead, you should read in a way that is half-way between skimming and memorizing. Let's use an analogy to understand what this reading process should be like.

Imagine that a friend invites you to play a game that involves you finding on object in their house in the shortest amount of time possible. The friend tells you that before the game

begins, you can spend three minutes in the house. How can you best use that time? Well, you probably would not walk into the kitchen and spend your three minutes going through the drawers and trying to remember where every item is kept. If you did this, you'd have no time at all to learn anything about the other rooms. This would be like trying to memorize what you read. You don't have time to do it, and it isn't the best strategy. On the other hand, you could walk in the front door and out the back without paying a lot of attention to what is where. That's like skimming, and it isn't a good strategy, either. It doesn't use your time well. Instead, the best thing to do would be to try to remember which room in the house was located in what place. That way, when the game starts, if your friend says that the first object to find is a hair dryer, you can walk straight to the bathroom since you know where it is and begin looking around. This is the strategy that you want for the reading passages: learn their layout, like you would learn the layout of a house, and then when you are asked a question, you will know where to go for the details. You are likely to see questions that ask you about details, but you don't need to have them memorized. You can always return to the passage to find the detail that you need.

Three. Your answer needs to be supported by evidence in the passage. You can check your work on this section by asking yourself, "What is the evidence for my answer?" You should be able to point to specific pieces of information in the passage that show why your answer is the correct answer. If you can't do this, it likely means that the answer that you have chosen is incorrect and you need to choose another option.

For example, if you chose an answer choice that said that the author didn't like to go hiking, you should be able to point to something in the passage that supports your position. Maybe that would be a sentence like this:

"I've never chosen the outdoors when a fine meal with a good friend was an option."

Or like this:

"I chose to spend time on the sailboat; the woods were too frightening for me."

Notice that neither of these options is as direct as to say, “I hate hiking.” They are both subtler than that, but both of them lead to the conclusion that the author doesn’t like hiking. This is the tricky part of these passages on the ASVAB: the passage is not likely to directly state the material in an answer choice. Rather, you are like a detective looking for clues in the passage that support the position in the answer choice. If you think you have settled on an answer, ask yourself, “If I had to add the word ‘because’ and then a statement after that to the answer choice, could I do it?” Now, the ASVAB will never ask you to do this—it is all multiple-choice questions. But if you can think of something like “the author does not like hiking because she states that she’d rather eat a nice meal with friends” or “the author does not like hiking because she was afraid of the woods,” then you can be more confident that you have selected the correct answer.

Four. Look for figurative meanings. There are two levels of meaning: the literal level and the figurative level. The literal level means that something is literally, actually true. The figurative level is being used when words mean something other than their literal meaning. This difference is easier to understand when we think about some examples.

If I were to say, “She’s driving me up a wall!” I do not mean that I am in a car and that the person driving it is actually driving the car up an actual wall. Rather, it is an expression that means that she is making me crazy. So this is an example of figurative language. On the other hand, if two children were playing with toy cars and I said, “She’s driving that car up a wall,” I am using the literal meaning of the words: she has a toy car in her hand and she is pushing it up an actual wall. It is important to distinguish the literal meaning from the figurative meaning of language.

Five. Be prepared to make inferences. An inference is a conclusion that you draw from the information that you are given. It is not the same as a guess. Let’s look at an example. Think about these three sentences:

He is wearing a catcher’s mask.

The stands are full of cheering spectators.

He winds up for the pitch.

Based on those sentences, you can draw the inference that the sentences describe a baseball game. This is a reasonable conclusion to draw from the sentences, despite the fact that the sentences do not specify that it is a game. On the other hand, if you were to say that the Yankees are playing the Dodgers, that would be a guess. There is no information in the passage that would lead you to conclude that the players belonged to those two teams as opposed to any other team. It is important to understand the difference between an inference and a guess. An inference is a conclusion that you draw based on the evidence in the passage. If you were to ask yourself, "What is the evidence for thinking that this is a baseball game?" you could point to the catcher's mask, the spectators, and the action of the pitcher. So there is evidence to support the inference that this is a baseball game. On the other hand, if you were to ask yourself, "What is the evidence for thinking that the Yankees are playing the Dodgers?" there is no information in the passage that you could point to in order to support that idea.

There will be questions on the ASVAB that ask you to make an inference. This is not the same as making a guess. An inference requires you to draw a conclusion based on the information in the passage. It isn't a guess. Always ask yourself, "What evidence in the passage supports my inference?" If you can't find anything, then it isn't a good inference.

Let's try another example of this. Here's the passage:

A universal basic income is a powerful but simple concept. In essence, the government would provide every household with a basic living allowance each month, paid for by a small tax on the super-wealthy. This proposal would simplify government and be fairer for the poor.

Now consider this question:

Which of the following statements would the author most likely agree with?

A. a wide variety of government programs is best

B. private charity is the best way to help the poor

C. taxing the wealthy is unfair

D. the government is too complicated

Answer: The best answer is D. Let's look at the wrong answer choices first, to determine why they are not statements that the author is likely to agree with. Option A states that a wide variety of government programs is best. But the passage states that the author thinks that simplifying government would be a good thing. This means that the author is not likely to think that a variety of programs is best, so we can eliminate this answer. Option B states that private charity is the best way to help the poor. But the passage states that a universal basic income is a good idea, and that is something done by the government, not by a private charity, so there is no evidence for this answer, and so we can eliminate it. Option C is that taxing the wealthy is unfair. But the proposal of a universal basic income, which the author supports, involves taxing the wealthy, so it is very unlikely that the author would agree with this. We can eliminate option C. That leaves us with option D, which states that the government is too complicated. Note that the passage states that the fact that a universal income would simplify government is one of the benefits of the program, so it is reasonable to think that the author thinks that the government is too complicated. This means that it is likely that the author would agree with option D. The important thing to note in this question is that none of the answer choices are directly stated in the passage. You have to make inferences about what is or is not true based on what you have read. In other words, you have to think about the passage and decide what is a reasonable conclusion to draw. It should be obvious at this point that this is not guessing. Rather, you need to imagine that you were called upon to defend your ideas—even though this won't actually happen when you take the ASVAB. Imagine a class discussion where a student states one of the answer choices and the teacher replies, "And how would you support that position? What is the evidence for it?" You need to be able to provide evidence for the answer that you have chosen.

Six. Be ready to summarize the passage. Now, if you have given some thought to the structure of the text, then summarizing the passage will be a bit easier because you will already know

how the text is organized. You may see questions that ask you to summarize the passage. In order to be able to do this, you will need to be able to distinguish the main idea from the details. Sometimes, this can be a bit tricky. Remember that the main idea applies to the passage as a whole while the details do not. If you are having a tough time distinguishing between the main idea and the details, you can ask yourself this question: “What happens if I remove it from the passage?” If you remove the main idea from the passage, you would have an entirely different passage. It wouldn’t be about the same topic. On the other hand, you can remove a detail without changing the overall meaning of the passage. Another way to test for the main idea is to imagine this situation: if someone asked you, “So what was that reading passage about?” how would you answer? A good answer to that question will be a summary of the passage.

It can be difficult to sum up the skills needed to do a good job on the reading comprehension questions on the ASVAB, because you need a variety of skills and strategies to work together in order to read well. It isn’t quite as simple as following a set of steps, as you would to solve an algebra problem. Figure Sixteen illustrates the skills and knowledge that you need to use to approach the paragraph comprehension section:

Figure Sixteen: Reading Comprehension Skills

KEY TAKE-AWAYS

One. Think about the structure of the text. Normally, a text will have one of these five structures: compare or contrast, sequence, cause and effect, problem and solution, or description.

Two. Your reading style should be somewhere between skimming and memorizing.

Three. Your answer needs to be supported by evidence in the passage.

Four. Look for figurative meanings.

Five. Be prepared to make inferences; an inference is a conclusion that you draw from the information that you are given.

Six. Be ready to summarize the passage.

QUIZ

Answer the first three questions based on this passage:

Until the twentieth century, the field of geology lacked a unifying theory to explain the major phenomena of the earth. But by the 1960s, the idea of plate tectonics, supported by evidence of seafloor spreading, made it possible to understand the Earth as a unified system. The basic idea is simple: the outer crust of the Earth is divided into plates, some as large as continents. These plates move, but very slowly; some plates show virtually no motion while others may move up to one meter per year. When plates interact at their boundaries, they can cause volcanoes, earthquakes, ocean trenches, and the formation of mountains.

1. **Which of these options would be the best title for this passage?**

   A. How the Earth Formed

   B. Plate Tectonics

   C. What Causes Earthquakes?

   D. The Earth's Crust

   Answer: B. A question that asks you what the best title would be is really asking you about the main idea of the passage. While the passage touches on topics related to several of these answer choices, a title needs to reflect the main idea or big theme of a passage. Since the passage as a whole is about plate tectonics, option B is the best answer.

2. **How much might a plate move in a year?**

   A. one kilometer

   B. one hundred meters

   C. ten meters

   D. one meter

Answer: D. This is a detail question. You did not need to memorize precisely how far a plate could move when you first read the passage, but you should have been reading in such a way that, when you saw this question, you remembered the approximate location in the passage where the information was mentioned so you could return to that part of the passage and check the exact measurement. The passage stated that plates move up to one meter per year, so that is the correct answer.

3. Which of these discoveries would be most surprising to scientists?

A. evidence that seafloor spreading does not occur
B. a mountain caused by two plates interacting
C. a plate moving
D. an active ocean trench

Answer: A. To answer this question correctly, you will need to observe that it is asking for something that would surprise scientists, or something that they have no reason to currently believe is true. The passage states that seafloor spreading is evidence for plate tectonics, so scientists would presumably be surprised by evidence that it does not occur. On the other hand, the three other answer options would not be surprising to scientists because each one of them is something that they would fully expect to happen based on the current theory of plate tectonics.

Answer the next four questions based on this passage:

Increasing income inequality raises three main concerns. First, when the rungs on the ladder are at a greater distance, it is much more difficult to climb the ladder. And the evidence supports the idea that children raised in disadvantaged households are less likely to ascend to the higher rungs on the economic ladder. This interrupts the narrative of the American dream. Second, when the lives of the wealthy rarely overlap in meaningful ways with the lives of the poor, the wealthy are not only unaffected by, but also unaware of, the problems of poverty and, therefore, less likely to intervene. For example, in a town small enough to have one public and no private high schools, the wealthy will be involved in the school community and advocate

for its support. On the other hand, today many wealthy Americans simply do not interact with the schools in a neglected rural community or inner city. Finally, the ability of the wealthy to dominate the political process is a grave concern. When the wealthy have the best senators that money can buy, it is unlikely that those leaders will advocate for helping the rest of society.

4. **What is the purpose of the reference to ladders in this passage?**

A. to show the problems the poor have in buying household goods

B. to show that poor children don't have access to physical education equipment

C. to figuratively describe the problems that the poor have in "climbing" the income ladder

D. to figurately describe the health problems of the poor

Answer: C. This question tests your ability to distinguish literal from figurative language. In this passage, the reference to a ladder is not to a literal, actual ladder but rather to a ladder used figurately to describe the process of climbing from one income level to another.

5. **Which of these statements would the author most likely agree with?**

A. income inequality causes several problems

B. it's acceptable for poor communities to have less money for their schools

C. it's acceptable for the wealthy to have more influence on the political process

D. the American dream is a bad goal

Answer: A. This question is assessing your ability to draw an inference from the information in the passage. To answer it correctly, it isn't enough for you to identify whether something was mentioned or not mentioned in the passage—all of the incorrect answer options were mentioned in some way in the passage, but they are still incorrect. Rather, answering this question correctly requires you to understand what message the author is trying to get across. In this case, the author is presenting several problems caused by income inequality.

6. **How many concerns does the author present about income inequality?**

A. one

B. two

C. three

D. four

Answer: C. This is a detail question. The first sentence of the passage says that there are three main problems with income inequality, so option C is the correct answer.

7. **What advantage does the author find in a town with only one high school?**

A. there will be little traffic

B. there won't be sports rivalries

C. there will be more educational options

D. the wealthy will be more involved with the school

Answer: D. This is an example of a detail question. From your first reading of the passage, you should have remembered the approximate location where the author wrote about schools. Then, when you read this question, you could return to that part of the passage and find the specific information that you need. In this case, the author mentions that a benefit of a one-high school town is that all students attend the same school, which, the author argues, means that wealthy families will be more involved in that school.

Use this passage to answer the remaining questions in this section:

She crept into the theater as silently as possible. She was tempted to turn on her phone's flashlight app to navigate around the sticky spots of soda on the floor, but she didn't want to incur the wrath of other audience members. Instead, in mourning for her new loafers, she eased her way back to her seat. Once there, she faced the task of balancing popcorn, soda, candy, and ice cream without spilling anything.

8. What is the most likely setting for this passage?

A. an empty movie theater

B. a basketball game

C. a movie theater during a movie

D. a religious service

Answer: C. The evidence in the passage suggests that this passage is set in a movie theater during the movie. This explains why the character is trying to be quiet and not turn on the light.

9. Which word best describes the character in the passage?

A. energetic

B. considerate

C. rude

D. confused

Answer: B. You can find evidence in this passage that the character is considerate: she doesn't want to disturb the other movie goers by making noise or turning on a light. On the other hand, there is no evidence in the passage that shows that she is energetic, rude, or confused.

10. Which word best describes the movie theater?

A. antique

B. modern

C. dirty

D. cold

Answer: C. The character is trying not to step in soda on the floor, so there is evidence that the theater is dirty. There is no evidence in the passage suggesting that it is antique, modern, or cold.

ELECTRONICS INFORMATION (EI)

In this section, you will have eight minutes to answer sixteen questions if you are taking the computerized version of the test. If you are taking the written version, you will have nine minutes to answer twenty questions. Both versions will test your familiarity with basic concepts of electronics, which we will review in this section. To give you a feel for the kinds of questions that you will be answering, we can take a look at the three sample questions on the official ASVAB website. The first one shows you a schematic and asks you what the correct measurement of the current is. The second question is about solid-state diodes, and the third question asks you what is measured by an ohmmeter.

Let's begin with the basics. Within an atom, there are electrons, protons, and neutrons. Electrons have a negative electrical charge, and atoms can gain or lose electrons. Have you ever rubbed your hair against a balloon and had your hair stick out straight from your head? If so, you have seen electron transfer in action. Electricity is simply the flow of electrons.

We say that an object is a good conductor if it allows electrons to flow easily. All metals are conductors. If an object does not allow electrons to move through it, then we call it an insulator. Some common insulators are glass, wood, plastic, air, and rubber. This means that you can get electricity to flow down a metal wire, but you couldn't get electricity to flow well through a piece of wood. This is why the wires in your electronics are made out of metal and not wood. If you have ever looked at an electrical wire, you may have noticed that the wire itself is made of metal and then is normally surrounded by plastic. Plastic is a good insulator, and metal is a good conductor. Electricity always follows the path of least resistance in situations where there is more than one path available, which means that it will stay in the metal wire and not flow through the plastic.

A volt is a unit of measurement. A volt measures electrical potential. That concept can be a bit difficult to understand. You can think of it as a measure of the pressure of the electricity in a circuit. Or, you can think of it as the strength of a current of electricity. Volts are measured with a voltmeter. You are probably familiar with double A batteries. A double A battery has one point five volts. But a car battery is normally twelve volts. A standard electricity outlet in your home will have one hundred and twenty volts. A bolt of lightning can contain a billion volts of

electricity. These numbers give you a sense of the relative strength of a small battery, a car battery, and a bolt of lightning.

Electricity flows from an area of high potential energy to an area of low potential energy until both have the same potential energy. This flow is called a current. Current can be measured in a unit called amps. The tool for measuring amps is called an ammeter. When current flows in a closed loop, we call that a circuit. Imagine a wire that attaches to a battery on one end and a small light on the other. Now imagine a second wire connecting the light to the other terminal of the battery. This would be an electrical circuit. Electricity will flow through the circuit, and the light will be lit. Anything we place in the circuit that does some work, such as the light, is called a load. If we want to be able to turn our light on and off, we can put a device that interrupts the circuit into the circuit. This is called a switch. Yes, a light switch like you find on the wall of your house is an example of a switch.

We can draw a diagram of a circuit. This is called a schematic. Figure Seventeen has a sample schematic diagram:

Figure Seventeen: A Schematic Diagram

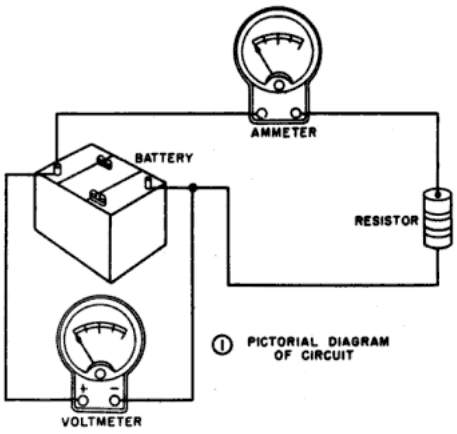
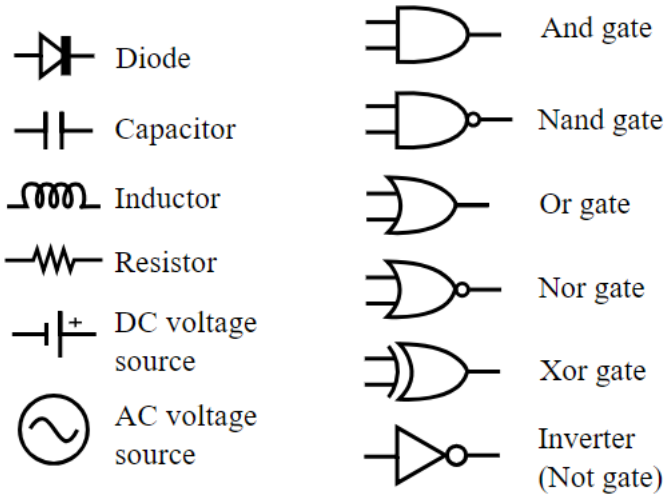


Figure 48. Diagram of a basic circuit.

Source: USAF (public domain)

Figure Eighteen shows some of the symbols commonly used in schematic diagrams:

Figure Eighteen: Symbols Used in Schematic Diagrams



Source: Wikimedia Commons

You may see a schematic on the ASVAB. If you are not already familiar with how to interpret one of these diagrams, you may want to learn how to do that. If you Google "electronics schematics," you will find resources to help you do this.

Electric current can either flow continuously in one direction, or it can continually reverse directions. We call it a direct current if it flows in one direction. Our simple circuit of a battery, two wires, and a light is an example of a direct current. The other kind of current—the one that keeps switching directions—is called an alternating current. The electricity that comes from power plants and is used in homes and businesses is an alternating current. It isn't something you notice because it happens so fast, but the electrical current in your home switches direction sixty times per second. You will sometimes see direct current abbreviated as D-C and alternating current abbreviated as A-C.

Let's return to our little circuit with the battery, two wires, and a light and imagine adding something to this circuit, such as a heater. A heater converts electrical energy into thermal energy, which is just another way of saying that a heater changes electricity into heat. Anything

that, like this heater, slows down the flow of electrons is called a resistor. We can measure the amount of resistance using a unit called ohms, which is spelled o-h-m-s. We can measure ohms with an Ohmmeter. If we want to reduce the flow of electricity in a circuit, we can put a device called a resistor in the circuit. There are several different things that determine how much resistance there is. First, there is less resistance in a cooler material than in a warmer material. A longer wire has more resistance than a shorter wire. A narrow wire has more resistance than a wider wire. The composition of the wire also determines resistance, since, as we have already discussed, some materials have more resistance than other materials.

We can add a device called a capacitor to our circuit. This is a device that can store a charge.

We call a circuit a series circuit if the current has to pass through all of the resistors in the circuit. If the current can separate into different paths so that not all of the current has to go through every resistor in the circuit, then we say that that is a parallel circuit. To help visualize this, think about driving a car. If there is only one road that will get you from where you are to your destination, that is similar to a series circuit because there is only one path that you can take to the destination. On the other hand, if there are three different roads that would lead to your destination, that is like a parallel circuit. Some cars will be on each of the three roads; all of the cars won't be on the same road. Each car will only take one road, just as each electron in a parallel circuit will take only one of the possible paths.

Ohm's Law is an equation that describes the relationship between the voltage, the current, and the resistance. This means that if you know two of those values, you can use Ohm's Law to determine the third value. The formula is voltage equals current times resistance. Imagine this situation: you are using a nine-volt battery to supply power to a small radio. The resistance is three ohms. How much current flows through the radio? We can solve this problem using Ohm's Law. Since voltage equals current times resistance, we can say that nine equals the current times three. Since three times three equals nine, we know that the current equals three.

Now, let's think about power. You probably hear and use the word "power" all of the time, but when we are studying electricity, the word "power" has a very specific meaning. Power is the rate at which electrical energy is transferred by a circuit. Power is measured in watts. You can use the formula power equals voltage times current to determine power, voltage, or current if you know the other two values.

We say that a short circuit has occurred when enough of the resistance is removed that too much voltage moves through the circuit. A short circuit can be dangerous. There are several ways that short circuits can be prevented. A surge protector is a device that is placed between the source of the electricity and a device that uses the electricity. If there is too much current flowing through the circuit, the surge protector diverts the electricity. Many people use surge protectors to protect expensive electronics, such as computers. Another way to prevent a short circuit is with a circuit breaker. A circuit breaker is a device that opens the circuit if there is too much current flowing through it. A fuse can also be used to prevent a short circuit. A fuse is similar to a circuit breaker, except that a fuse can only be used once before it needs to be replaced.

You may see some questions on the ASVAB related to safety with electricity. For example, if the coating of a cord is damaged, that coating may not contain the electric current, and it could cause a short circuit. It is also very dangerous to mix electricity and water since water is a good conductor. This means that if you drop your hair dryer into the bathtub, the water in the tub may conduct the electricity flowing from the hair dryer into your body. Similarly, you should never put anything other than a plug into an electric outlet, since this can cause electricity to flow through whatever it is that you have put into the outlet and into your body. There is a system of color-coding electrical wires so that you can tell the wire type just by looking.

Next, let's review the names of the parts of an electronic device. When something can conduct current more efficiently than an insulator but not as well as a conductor, we call that material a semiconductor. The two types of semiconductors are called the n-type and the p-type. These words refer to the materials that they are made out of: both kinds include silicon, but the n-

type includes another element that gives the silicon extra electrons. We call it n-type because it is negative due to the presence of those added electrons. The p-type stands for positive-type.

If we place an n-type and a p-type semiconductor side-by-side, that is called a diode. When we connect that diode to voltage, the electrons can flow from the n-type to the p-type, but only in that direction. This means that we can use a diode to change an alternating current to a direct current.

When we put three semiconductors in a row, so that they alternate, that is called a transistor. By alternate, we mean that the order is n, p, n or p, n, p, so that the types alternate. A transistor is like a switch. If there is a small change in the current to the middle layer, it causes a large change through the entire transistor.

Key Take-Aways

One. Electricity is the flow of electrons.

Two. Conductors allow electrons to flow easily. If an object does not allow electrons to move through it, then we call it an insulator

Three. A volt measures electrical potential. Volts are measured with a voltmeter.

Four. The flow of electricity is called a current. Current is measured in a unit called amps with a tool called an ammeter.

Five. A circuit is a closed loop that electricity can flow through.

Six. Resistors slow the flow of electricity. Resistance is measured using a unit called ohms, with an Ohmmeter.

Seven. In a series, the current has to pass through all of the resistors in the circuit. In a parallel circuit, the current can take one of several routes through the circuit.

Eight. Ohm's Law states that voltage equals current times resistance.

Nine. Power is the rate at which electrical energy is transferred by a circuit. Power is measured in watts.

Ten. A short circuit occurs when enough of the resistance is removed that too much voltage moves through the circuit.

Eleven. A semiconductor can conduct current more efficiently than an insulator but not as well as a conductor. The two types are called the n-type and the p-type.

Twelve. A diode consists of two semiconductors; a diode can change an alternating current to a direct current.

Thirteen. A transistor consists of three semiconductors in a row.

QUIZ

1. A material that is extremely difficult for electricity to flow through is called what?

A. conductor

B. insulator

C. voltage

D. wattage

Answer: B. When it is difficult or impossible for electricity to flow through a material, we call that material an insulator.

2. Which kind of current always flows in the same direction?

A. direct current

B. alternating current

C. Ohm's current

D. voltage current

Answer: A. There are two kinds of electrical currents: direct and alternating. Direct current always flows in the same direction.

3. Which of the following is Ohm's Law?

A. force equals mass times acceleration

B. area equals pi times the radius squared

C. voltage equals current times resistance

D. power equals voltage times current

Answer: C. Ohm's Law states that the voltage is equal to the current times the resistance, so option C is correct.

4. What is power measured in?

A. amps

B. volts

C. meters

D. watts

Answer: D. Option D is the correct answer because power is measured in watts.

5. What does an ammeter measure?

A. volts

B. watts

C. amps

D. meters

Answer: C. An ammeter measures amps, so option C is the correct answer.

6. Which of these has more resistance?

A. a shorter wire as opposed to a longer wire

B. a cooler wire as opposed to a warmer wire

C. a thicker wire as opposed to a thinner wire

D. a plastic wire as opposed to a metal wire

Answer: D. Wires have more resistance if they are longer, warmer, and thinner, so the first three options are not correct. But metal is a better conductor than plastic, so a plastic wire would have more resistance than a metal wire.

7. Which of these can be used to prevent a short circuit?

A. ammeter

B. voltmeter

C. load

D. fuse

Answer: D. There are three ways that a short circuit can be prevented: a fuse, a circuit breaker, and a surge protector.

8. Which of these can change an alternating current to a direct current?

A. a load

B. a resistor

C. a diode

D. an ammeter

Answer: C. A diode permits current to flow through it in only one direction, so it can be used to change an alternating current to a direct current.

9. What is the purpose of a schematic?

A. to control the flow of current

B. to add resistance to a circuit

C. to visually show how a circuit works

D. to increase the current

Answer: C. A schematic is a diagram that illustrates the parts of a circuit.

10. What are the names for the two types of semiconductors?

A. p-type and n-type

B. silicon and magnesium

C. off and on

D. volt and watt

Answer: A. The two types of semiconductors are referred to as p-type and n-type.

AUTOMOTIVE AND SHOP INFORMATION (AS)

In the paper version of the test, the automotive and the shop sections are combined. In the computer version, they are separated into two sections. In this guide, we will treat both topics in one section. This section covers the basic knowledge that you need to work in an automotive shop or workshop environment. To give you a sense of the kinds of questions that you will find in this section, the sample questions on the official ASVAB page ask about shock absorbers, the location where combustion takes place on a diagram, spark plugs, what sanding blocks are used for, kinds of clamps, and kinds of handsaws.

If you have experience working or taking classes in an automotive shop or a workshop, this section should be quite easy for you. If you don't have that experience, then you might want to do a little extra preparation before you take the ASVAB, especially if the score for this portion is included in the required score for the occupational track that you are interested in. If possible, see if you can spend some time observing or helping in a mechanic's shop or a carpenter's shop. If that isn't possible, see what resources you can find online. There are many how-to style videos on YouTube that will show you the basic tools of the trade and how they are used. If the automotive and shop scores are not considered for the occupational track that you are interested in, then it may be a better strategy for you to spend your study time preparing for other sections of the test.

If you don't have experience in an auto shop or workshop, this section can be very intimidating. After all, you have spent years studying math and reading in school, so the material on those sections will not be entirely foreign to you, even if you have forgotten some of the details. On the other hand, many people have absolutely no experience in auto shops and workshops. The important thing is not to get intimidated. You may know a lot more than you think you know. And, the material in this section is pretty basic—it does not require a lot of expertise to do well. Let's review the basics of both auto shop and work shop so that you can do your best on this section of the test.

AUTOMOTIVE

In this section, we will review the basic structure of automobiles by looking at the systems of a car. See figure Nineteen, which lists the main systems of an automobile:

FIGURE NINETEEN: MAIN SYSTEMS OF AN AUTOMOBILE

You can think of a vehicle as, in its most basic terms, a box that is capable of moving people and objects at high speeds. Of course, today's modern cars are a lot more technologically sophisticated than that, but the basics are the same: you have a passenger and cargo area, an engine, and wheels. The engine converts fuel to energy that is transferred to the axle, and from there to the wheels, so that the car can move forward. If you have even looked underneath the hood of a car, you might have thought that it looked like there were hundreds of complicated parts in there. But the basics of most vehicles are pretty much the same, and it really isn't all that complicated.

Let's begin our review of automotive systems with the ignition system. The purpose of the ignition system is to start the engine. When the operator of the vehicle starts the ignition

system—usually by turning a key, but in some newer cars by pressing a button—energy from the battery is sent to the ignition coil. The purpose of the coil is to turn the energy into a spark. The distributor is used to send the spark to the spark plugs. The spark, from the spark plugs, is used to ignite the fuel vapor. This creates combustion, which is what powers the car. So, the job of the ignition system is to start the process that provides energy to the car.

Next, let's focus on the engine. The purpose of the engine is to supply energy so that the car can move. Most vehicle engines are internal combustion engines, which means that the energy comes from burning a liquid fuel. Historically, the internal combustion engine has been extremely important in shaping the modern world. Today, there are some alternatives to internal combustion engines, and there are concerns about the impact that gasoline has on the environment. You may be familiar with electric vehicles, which are powered by a battery. A hybrid has an internal combustion engine and a battery. To function, an internal combustion engine requires air, fuel, and an ignition source. The core part of an engine is its cylinders, with cars usually having four to eight cylinders. To visualize a cylinder, think about the shape of a soda can. Inside the cylinder is a piston that can move up and down. Once the spark plug provides the spark that ignites the fuel vapor, the car can use the energy as its power source. Most cars use a four-stroke combustion cycle to convert fuel into energy that can cause the car to move. The four phases of that process are the intake, compression, combustion, and exhaust. On the intake stroke, air and fuel are taken in to the cylinder. On the compression stroke, the movement of the piston compresses the mixture of fuel and air. This means that the piston forces the mixture of fuel and air into a small space. This increases their pressure. The third stroke, combustion, occurs when the spark plug gives off the spark, which causes the fuel to combust. You can now see why the prior step was important: the fuel and air mixture combusts better when it is under higher pressure, and that pressure was caused by the piston forcing it into a smaller space. You can even think of this as an explosion. Of course, it has to be a very controlled explosion in order to keep the occupants safe. This explosion pushes the piston down. This is the part of the process where mechanical energy is used to cause the motion that allows the car to actually move.

Of course, this creates an up-and-down motion. Cars don't need an up-and-down motion—they need a rotary motion to turn the wheels on the axle. The crankshaft is the part of the car that converts the motion from up-and-down to round-and-round. The technical terms for this are reciprocating motion and rotational motion. The final step of a four-stroke combustion process, exhaust, allows the waste products to leave the cylinder. We'll review the rest of the exhaust system soon. If you aren't already familiar with this four-stroke process, it can be difficult to visualize. There is an animation on the Wikipedia page for four-stroke engine that you may find very useful in helping you to understand this process. While motorcycles and some other vehicles can have an engine with one cylinder, modern cars have four or more. Of course, when you have more than one cylinder in an engine, the cylinders have to be arranged in some way so they can work together and not interfere with each other. If they are arranged in a row, this is termed an in-line engine. This arrangement is commonly used in airplanes. If the cylinders are in two rows, they will be set at an angle and this is called a V-type engine. It gets the name because if you look at it from a certain angle, the cylinders look as if they are forming a V because they are set at an angle to each other.

Let's go back to the part of the process where the fuel is mixed with air. This has to be done in a very precise way for the engine to work properly. The carburetor is the place where this mixing occurs. Here, air is mixed with liquid fuel. Were you wondering how the fuel got to the carburetor? The fuel pump moves the fuel from the fuel tank to the carburetor. Some older motorcycles just use gravity to get the fuel from the tank to the carburetor, but most cars have fuel pumps to do this.

The transmission system moves the mechanical energy that was created by combusting the fuel from the engine and to the wheels.

Next, let's look at the lubrication system. The purpose of this system is to stop the results of friction from damaging parts of the car. If you imagine two pieces of metal rubbing against each other, you can think about the damage that this would eventually cause to both pieces of metal. The job of the lubrication system is to be sure that this doesn't happen. Oil lubricates parts that would otherwise come in direct contact with each other and cause damage. The

parts of the lubrication system include the oil pan, oil pump, pressure regulator, and oil filter. The oil travels through this system. In addition to lubricating parts to prevent damage, it also cleans and cools various engine parts. Without oil to remove excess heat from the engine, the engine could overheat cecause, as you can imagine, the process of internal combustion leads to a lot of heat. The oil and the oil filter have to be changed regularly in order for the vehicle to function properly.

Next, let's think about the braking system. You probably know that the purpose of this system is to stop the vehicle. The work of the braking system begins when the driver presses the brake pedal. This activates a piston in the master cylinder, which in turn moves brake fluid through the brake lines. This fluid powers pistons, which are connected to the disc brake pad or brake shoe. This very quickly slows the wheel and ultimately stops its rotation. The time it takes to stop the vehicle depends on several factors, including how fact the car was moving and the road conditions.

The next system, the cooling system, is responsible for ensuring that the car doesn't overheat. Even though automakers try to make vehicles that are as efficient as possible in turning heat into mechanical energy, it is still the case that about seventy percent of the energy in the fuel is turned into heat. If this heat were allowed to build up, it would make it impossible for the car to function. So, the cooling system removes heat from the engine and the transmission. The heat is moved to the outside of the car. A liquid moves through the engine and absorbs the excess heat. Then, the liquid goes through the radiator, which transfers the heat from the liquid to the air. There is usually a separate liquid circuit for the transmission.

Another important system is the suspension. The purpose of this system is to maintain enough friction with the road so that the driver does not lose control of the car. Another purpose is to keep the ride smooth. The three important parts of the suspension system are the springs, shock absorbers, and struts. A shock absorber reduces how much the car vibrates. It does exactly what the name sounds like: it absorbs shocks. A strut is similar to a shock absorber, but it also provides structural support for the car.

Now, let's think about the car's electrical system. The battery is part of this system. As already mentioned, the battery is needed to start the car. Other elements of this system are the starter and alternator. You can think of the starter as a small motor used to start the engine. The purpose of the alternator is to keep the battery charged. The electrical system also includes whatever lights and sensors the can has.

The final system is the exhaust system. The purpose of this system is to remove the waste products that are produced when the car runs. This system consists of pipes that move waste products to the rear of the vehicle. The muffler is another part of the exhaust system, and it is responsible for minimizing engine noise. Catalytic converters are used to reduce the amount of toxic material in the car's exhaust system before it is released from the car.

This concludes our discussion of the basic systems of a vehicle.

SHOP

Now we will review the basic tools used in a workshop.

There are several different tools whose main function is to separate things. One category of separating tools is saws, and there are many different kinds of saws. You have probably seen a basic handsaw, which is very useful for cutting wood. A hacksaw is similar in design, except that it has a very thin blade; it is most often used for cutting plastic or metal. Now, let's move on to electrically-powered saws. A jigsaw is useful if you need to cut a custom shape from a sheet of wood. A circular saw is similar to a handsaw in usage but is much more powerful. A table saw is not something that you can move easily, but it is very powerful and versatile. Other tools used to separate materials include scissors and sheers. A plane is used to shape wood or to smooth it. A file is used when you need to remove very small amounts of material from an object; it usually has a textured surface. A router can be hand-powered or electrically-powered, and it is used to hollow out an object. A chisel is used for removing material from an object; it has a blade on the end. And, finally, a torch or blowtorch is used to apply heat to a material. A drill and an auger are used for making holes.

Next, let's consider the tools used to join things together. There are several different kinds of hammers. The most common type is the claw hammer. You can use one side of it as a lever. A ball peen hammer has a round end, and it is sometimes used to shape metal. And a mallet is basically a block on the end of a handle. The two main kinds of screwdrivers are called flat and Phillips head. A flat head looks like a minus sign and a Phillips head looks like a plus sign. Both kinds are used for adding and removing screws. Wrenches are used to grip and move objects. There are several different kinds. A socket wrench has a detachable socket, so you can choose precisely the size that you need. Once assembled, the socket is placed over a nut or bolt so that you can tighten or loosen it. An Allen wrench has a hexagonally-shaped end that matches a bolt. A combination wrench has two useful ends to it. A monkey wrench is adjustable. Pliers are a tool used to get a good grip on a small object. Needle-nose pliers have a very fine tip and so are useful for working with small items or in small spaces. The technical name for what are often just called "pliers" is slip-joint pliers. Because they can be adjusted, they can be customized to work with a variety of sizes of materials.

There are several different things that can be used to attach objects to other objects; these include screws, nails, bolts, and rivets.

A variety of tools are used to measure objects. The most common is a tape measure. Less common is a steel rule. This is basically a yard stick made out of metal. It is useful for situations where you do not want a tape measure, which can bend. The most important thing to remember when you are measuring is that you need to be sure that the zero mark on the tape measure or ruler is in the proper position. It may not be on the very end of the ruler or the tape measure, so you need to line it up carefully. A level is used to see if an item is at the correct angle. Some are electronic, but the traditional kind has a bubble of air in a cylinder of liquid. There are two marks on the cylinder. If the level is placed so that it is level with the ground, then the bubble will appear in between the two lines. If it does not, it means that the level is tilted. Levels usually have two of these chambers, so that you can tell if something is level with the ground and also if it is perpendicular to the ground. A plum bob is a weight hanging from a string that can be used to determine if something is running precisely up and down, since the

string will hang straight down. A square, which is also called a carpenter's square, is used to determine ninety-degree angles. It looks like two steel rules joined to make a right angle. There is some overlap in the functions of a square and a level because both can help you precisely identify ninety-degree angles, but often one tool is better for a particular job. A caliper has two adjustable parts and is used to measure the distance between two points. What is nice about a caliper is that you can set the caliper for the distance that you want and then move the caliper, which transfers the exact distance to another object. If, for example, you wanted to mark fifty pieces of lumber at precisely three and three-sixteenths of an inch, it would probably be easier to do that with calipers than with a tape measure or a steel rule, since you could set the caliper to the proper distance just one time, and then move the caliper from board to board. You wouldn't need to reread the distance on the tape measure each time. A micrometer is used for making very precise measurements. It is an important tool when you need an extremely precise measurement, such as to the thousandth of an inch.

You are probably already familiar with common yard tools and their uses, such as shovels, rakes, hoes, and axes, so we will not spend time on those. If you are not familiar with these items, you should easily be able to learn about them on the Internet.

Key Take-Aways

One. The purpose of the ignition system is to start the engine.

Two. The engine supplies energy so that the car can move.

Three. The transmission system moves the mechanical energy that was created by combusting the fuel from the engine and to the wheels.

Four. The lubrication system stops the results of friction from damaging parts of the car.

Five. The braking system stop the vehicle.

Six. The cooling system ensures that the car doesn't overheat.

Seven. The suspension maintains enough friction with the road so that the driver does not lose control of the car.

Eight. The electrical system uses energy to start the car and maintain the battery.

Nine. The exhaust system removes the waste products that are produced when the car runs.

Ten. Tools for separating things include saws, scissors, files, routers, chisels, and blowtorches.

Eleven. Tools for joining things include hammers, screwdrivers, wrenches, and pliers.

Twelve. Tools for measuring include tape measures, levels, plum bobs, squares, calipers, and micrometers.

QUIZ

1. Which car system is responsible for removing waste products from the car?

A. the engine

B. the battery

C. the exhaust system

D. the electrical system

Answer: C. The purpose of the exhaust system is to remove waste products from the car.

2. Which statement best describes a blowtorch?

A. it is used to measure small distances

B. it is used to remove small amounts of wood

C. it is used to apply heat to a surface

D. it is used to remove nails

Answer: C. A blowtorch applies heat to a surface.

3. The oil pump is part of which system?

A. ignition

B. exhaust

C. brakes

D. lubrication

Answer: D. The oil pump circulates oil in the engine. The purpose of this is lubrication.

4. If you want to determine if a shelf has been installed at the correct angle, which tool should you use?

A. needle-nose pliers

B. ball peen hammer

C. a level

D. a hoe

Answer: C. A level is used to determine the angle of some object relative to another object.

5. What is the purpose of the ignition system?

A. to lubricate the engine

B. to stop the vehicle

C. to remove waste from the vehicle

D. to start the vehicle

Answer: D. The purpose of the ignition system is to start the vehicle.

6. In what situation should a router be used?

A. to join two pieces of metal

B. to cut a groove in a piece of wood

C. to check if an angle is square

D. to remove screws

Answer: B. A router is a tool used to make grooves or holes.

7. What is the purpose of the spark created by a spark plug?

A. to ignite the fuel and air mixture

B. to minimize friction

C. to remove toxic particles

D. to activate the brakes

Answer: A. The purpose of a spark plug is to create a spark that will be used to ignite the fuel and cause combustion.

8. Which tool should be used to fasten a screw that has an indentation on its head that looks like a plus sign?

A. flat head screwdriver

B. monkey wrench

C. Phillips head screwdriver

D. needle-nosed pliers

Answer: C. A screwdriver is used to fasten and remove screws, and a Phillips head has an end that looks like a plus sign.

9. What is the final step of the four-stroke cycle?

A. intake

B. exhaust

C. combustion

D. compression

Answer: B. The four steps, in order, are intake, compression, combustion, and exhaust.

10. Which tool is best for cutting a custom shape in a piece of wood?

A. pliers

B. jigsaw

C. hacksaw

D. chisel

Answer: B. A jigsaw is used to cut specific shapes in wood.

MECHANICAL COMPREHENSION (MC)

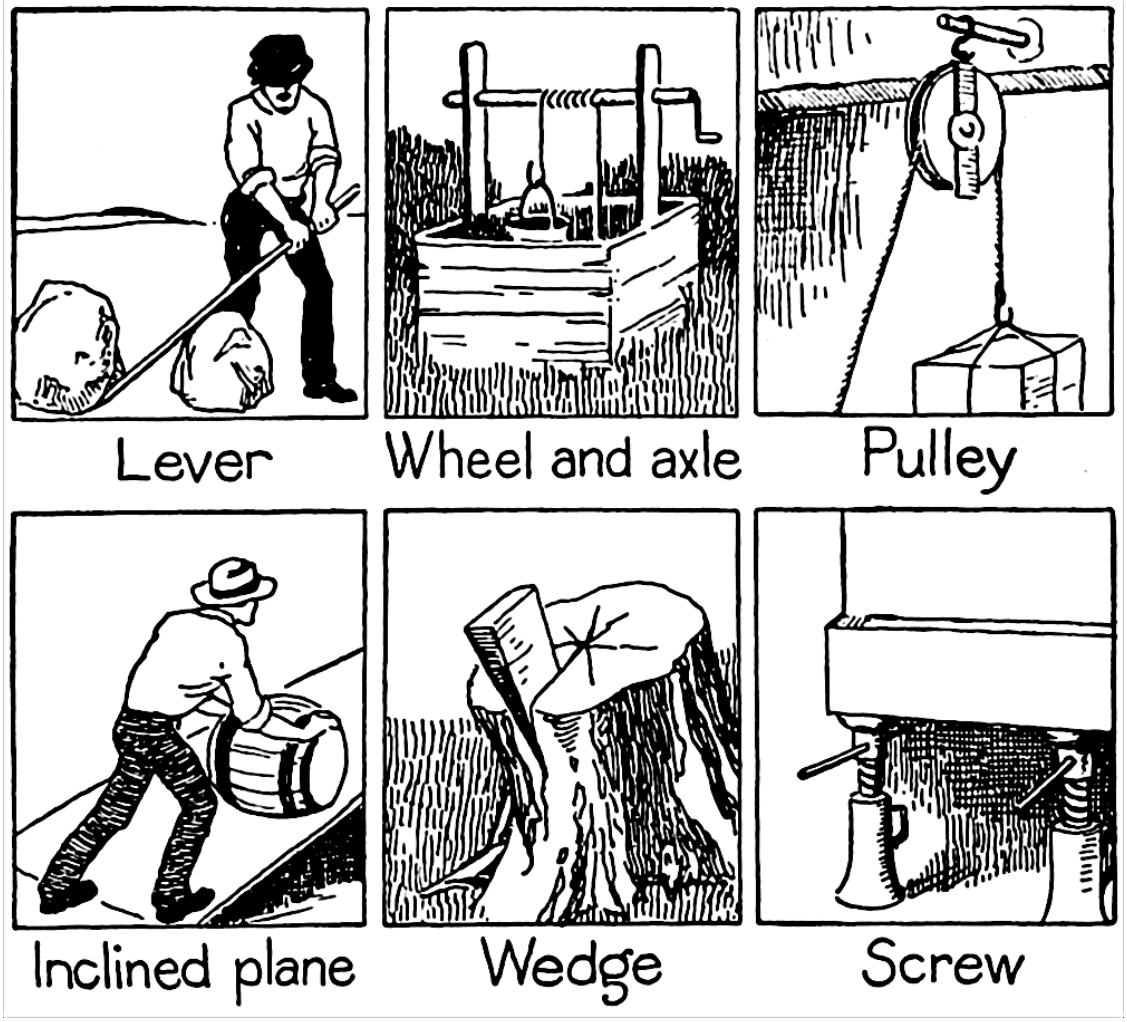
On the mechanical comprehension section of the ASVAB, you will have twenty minutes to answer sixteen questions if you are taking the test on a computer. If you are taking the paper version, you will have nineteen minutes to answer twenty-five questions. This section tests your ability to apply scientific principles from the field of physics to real-life situations. To give you a sense of the kinds of questions that you might encounter, let's consider the three sample questions on the official ASVAB website. The first one asks you how the concept of changing center of gravity might affect a crane. The second question asks how friction impacts a skier. And the third question asks how air pressure functions in a piston.

You may be feeling a bit intimidated by this section, especially if you haven't taken a physics class or if you have taken one, but you found it difficult. The good news is that a lot of the questions in this section have a common-sense aspect to them. For example, you may not have learned about or have remembered what the term "center of gravity" means, but you know that if you learn far enough over a balcony railing, you'll fall over the edge. So you already know something about the concept. You will be able to apply real-world knowledge to help you. And in this section, we'll review some basic concepts so that you can do your best on the ASVAB.

You'll remember from the general science section that the word "work" refers to using force to move an object, and the equation work equals force times distance describes that process. Power is the amount of work done in a certain amount of time, with the equation power equals work divided by time reflecting this fact. We often use horsepower to describe the amount of power something has. It's a funny word, but it was coined in the early days of steam engines to compare how powerful they were with how powerful horses were.

A machine is a mechanical device that applies a force. There are six simple machines, and a surprising number of the machines around you are just some variant of these machines. Let's look at each of the six simple machines now. You can see an example of each one in Figure Twenty:

FIGURE TWENTY: THE SIX SIMPLE MACHINES



Source

One. An inclined plane. A ramp is an example of an inclined plane. At its simplest, an inclined plane is just a surface that is higher on one end than it is on the other. This isn't exactly complicated technology, but it does make it easier to move an object when you move it up an inclined plane. When you use an inclined plane, you have to move an object a greater distance, but it takes less force to move it. If you were given the task of moving a very heavy box up to a truck bed that was eight feet off of the ground, it would be easier to use a ramp, despite the fact that you would have to walk a greater distance in order to go up the ramp. This is due to the mechanical advantage created by the inclined plane. Note that an inclined plane doesn't

have any moving parts. You could even make one by moving dirt. In fact, that is probably how the pyramids in Egypt were made, as ramps were created and huge blocks were dragged up them. Then, when they were finished, they removed the ramps. It may be strange to think of a pile of dirt as a machine, but when we are thinking about simple machines, we are thinking about something that makes work easier to do, not necessarily something that is complicated or that has electronic parts.

A lever. A lever has a bar that rotates around a specific point. Think about using the claw end of a hammer to remove a nail from a board. This is an example of a lever. A lever works by changing the direction of the force that is applied. It can also make it possible to apply less force. Think about two children sitting on a seesaw. Imagine that one child is three years old and the other is twelve. Obviously, our twelve-year-old will be a lot heavier than our three-year-old. If they both sit on the ends of the seesaw, the older child will be as low as possible, touching the ground with her feet, while the three-year-old will be up in the air. The seesaw will not be balanced. Now imagine that the older child moves toward the center of the seesaw. As a certain point, both children can be balanced, despite the fact that the younger child is much smaller. This balanced seesaw is an example of mechanical advantage. You are, in effect, lifting a heavier weight—the weight of the older child—using the weight of the younger, smaller child, due to their different locations from the fulcrum of the lever. You can use this principle with other levers in order to reduce the amount of force that you have to apply to do work. The lever is what makes this possible. By the way, the center point of the lever can be termed a pivot or a fulcrum. The other essential parts of a lever are the beam, the force, and the load. You only need those four elements to have a lever. Levers are divided into different classes, based on the relative locations of the fulcrum, force, and load. But the important thing to remember about levers is that they create a mechanical advantage by allowing a smaller force to move a load. This can happen because the force is applied farther away from the fulcrum than the load is. You will notice that the load is not moved as far as the force moves. Going back to our example of the larger and smaller child, the smaller child will move up and down a greater distance than the larger child will, since the smaller child is farther away from the

fulcrum. This is the kind of trade-off that happens with a lever: a smaller force is used, but it has to move over a greater distance.

A wedge. A wedge consists of two inclined planes that are connected. Or, another way to think about this is to think of a wedge as an inclined plane that you put under something or in between two parts of something in order to change the direction of the force that you need to apply to it in order to get it to move. A knife is a wedge and, as you know, it is very useful for separating things. A chisel is an example of a wedge. Imagine that you have a log and you want to separate it into two pieces so that the pieces will fit in a fireplace. If you tried to do that with your bare hands, it would be very difficult to do it. But if you use an axe, it is much easier. One of the advantages of the axe is that you can apply a force straight down on the log instead of applying force in the middle of the log and trying to pull it apart.

A screw. A screw is an inclined plane that circles a cylinder. If that is difficult to visualize, think about a lighthouse. Now imagine a ramp that swirls around the lighthouse and lets you walk from the bottom to the top. That is, in essence, a screw. With each turn of the screw, we are only moving a short distance up the side of the lighthouse, but it is much easier to carry a box up that ramp than to move it straight up the side of the lighthouse. Again, we have the tradeoff that we have to move a greater distance, but that the work we do is easier because of the mechanical advantage of the screw.

A pulley. A pulley is a rope and a wheel. Think about a pulley used to raise a bucket from a well. A pulley can create a mechanical advantage, and it can increase as the number of ropes and pulleys increases. Of course, each of those ropes will have to be moved a greater distance. That is always the trade-off. A pulley can also change the direction of the force being applied. Imagine that you needed to lift a heavy box off of the ground. It can be hard to move something straight up. But if you had a pulley attached to the ceiling, you could attach the box to the rope. Then, when you pulled on the rope, you would be pulling the rope straight down.

The final simple machine is a wheel and axle. In its most basic form, think of two wheels connected by an axle. You have to move the wheel a greater distance than the axle moves, but the force on the axle is multiplied.

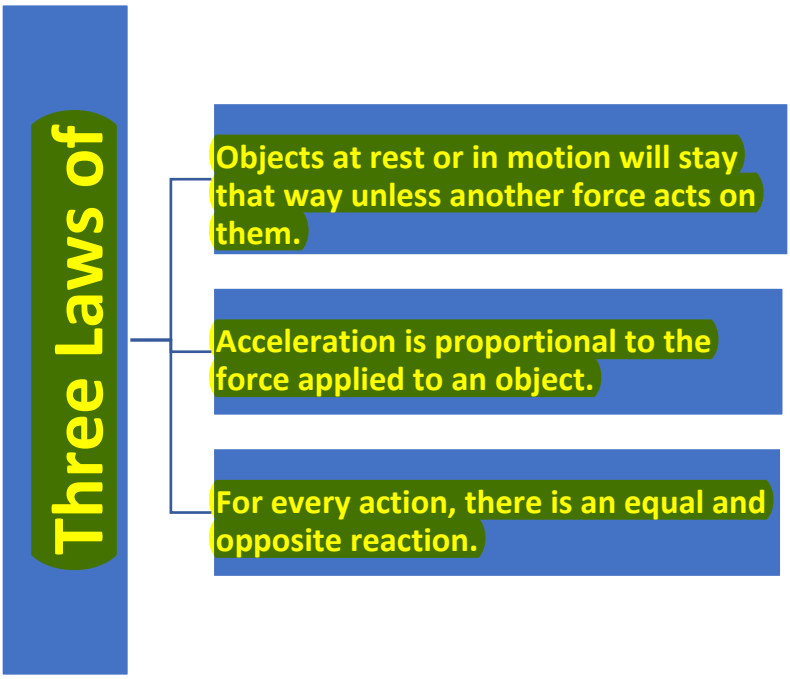
The basic principle for all of the simple machines is that you decrease the amount of force needed, but you increase the distance over which it has to be applied. This creates a mechanical advantage, and this is why simple machines are used in so many different situations. Sometimes, machines also change the direction of the force applied, which can make it more convenient to do the work.

If you combine two or even more simple machines, you have a compound machine. Think about a wheelbarrow: it contains a wheel and axle, but it also contains a lever. The combination of these two simple machines makes it even easier to do the work needed.

Next, let's think about gears. You have probably seen gears before. At its simplest, a gear is a wheel with teeth around the edge, placed there so it can interlock with another gear or an axle. The basic purpose of a gear is to transfer motion from one object to another.

Now, let's review the laws of motion. Here are Isaac Newton's three laws of motion. Newton's first law states that whether something is at rest or in motion, it will stay that way until another force acts on it. This is sometimes called the law of inertia. Newton's second law has to do with acceleration. This law states that acceleration is proportional to the force applied to the object, and it is inversely proportional to the mass of the object. More simply stated, this law states that the heavier an object is, the more force you need in order to move it. The third law of motion states that for every action, there is an equal and opposite reaction. Figure Twenty-One summarizes Isaac Newton's Laws of Motion:

FIGURE TWENTY-ONE: THE THREE LAWS OF MOTION



Friction is the force that resists motion. When two surfaces come into contact, there is friction between them, with more friction between surfaces that are less smooth. Think about pushing a heavy box across a carpet versus pushing it across a wood floor. It is much easier to push the box along the wood because there is much less friction. But even the wood floor has some friction since a surface that appears smooth is still uneven on a microscopic level. You have to exert extra force to move the box over these tiny little bumps on the wood floor. And you have to exert a lot of extra force to move the box over the carpet because its surface is much more uneven. You can think of friction as opposing the force that you are applying to the box.

We can measure a machine in terms of how much of the energy that is put into it actually becomes work as opposed to wasted energy. This is called efficiency. Imagine that you are pushing that heavy box across the carpet. You are wasting a lot of the energy that you are using because that energy is used to overcome the friction of the carpet—it isn't actually used to move the box forward. Now imagine that you put the box on a skateboard and you push the

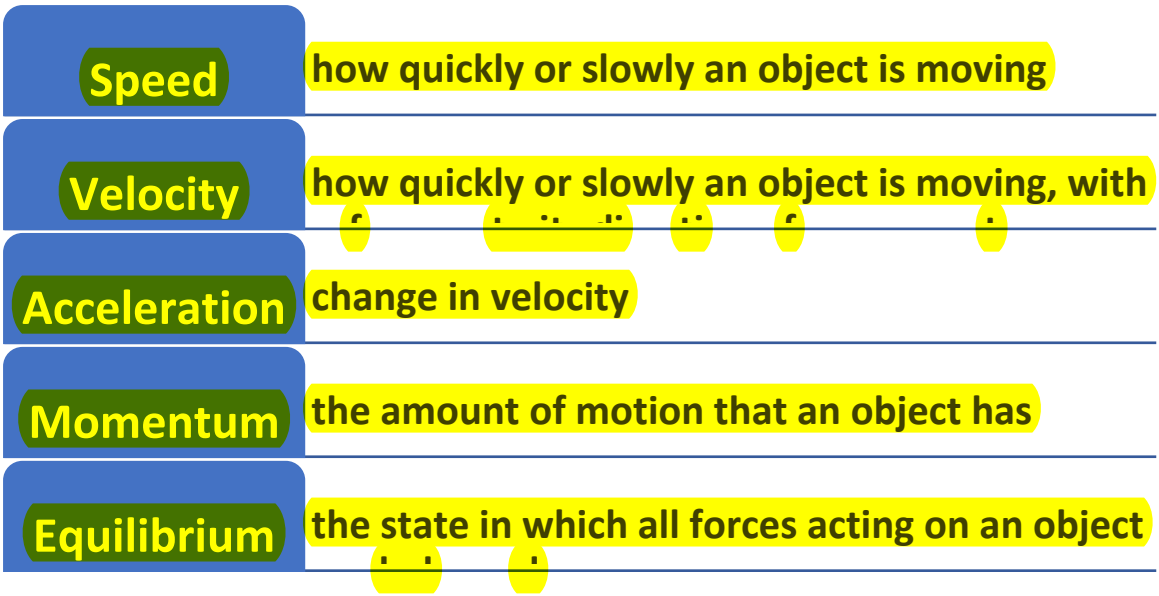
skateboard across the carpet. Think about how much of the skateboard is actually touching the carpet. It isn't very much—it's only the parts of the wheels that are in contact with the carpet. That means that there is much less friction to overcome as compared with the situation where one entire surface of the box was touching the carpet. Now, you can use much less energy to push the box across the carpet when the box is on a skateboard. We can say that this is much more efficient since you are wasting much less energy in overcoming friction. There is still some friction, but not nearly as much.

Efficiency is always less than one hundred percent because there is always some friction that needs to be overcome when work is done. But, as you can see from our example of the box on the carpet or on the skateboard, certain ways of doing work can be much more efficient than other ways.

When you have a force acting on an object in a way that causes the object to rotate, we call that force torque. Imagine wringing out a towel with your hands. If you are rotating the towel, the force applied to the towel is called torque. Think about opening a door. Do you normally push on the part of the door closer to the hinges, or the part of the door away from the hinges? Usually, you want to push on the part of the door away from the hinges. You intuitively know that this is a better way to open a door, but why? It is because you understand how torque works even if you haven't formally studied it. You know that it requires more force to push the door open if you push on it closer to the hinges. In either case, you'll get the same amount of work done—which is another way of saying that the door will open—but you'll need to apply less force to open the door if you push away from the hinges.

Next, let's review some concepts related to motion. While you may be familiar with words like speed, velocity, acceleration, momentum, and equilibrium, those words have very precise meanings when they are used scientifically—and those meanings can be a bit different from how the words can be used in normal conversation. See Figure Twenty-Two for a summary of these terms:

FIGURE TWENTY-TWO: TERMS RELATED TO MOTION



Let's begin with speed. The word speed refers to how quickly or how slowly something is moving. Velocity is a similar concept, except that velocity takes the direction of motion into account and speed does not. Think about this example. Imagine that a motorcycle is moving at fifty miles per hour. We know the speed: we have expressed it in terms of miles per hour. But at this point, we do not know the velocity because we do not know what direction the motorcycle is traveling in. But if we are told that the motorcycle is traveling north at fifty miles per hour, now we know the velocity because we know the speed and the direction. So velocity can be thought of as motion in a particular, known direction. If you don't know the direction of the motion, then you know the speed, but you do not know the velocity. When a measurement includes both speed and direction, we can call that a vector. Usually, vectors will be displayed with arrows that show the direction of the motion. You are likely to find some questions on the ASVAB that have diagrams with arrows and require you to think about the direction of motion. Do not be intimidated by these pictures. After all, you have lived in a world with motion and velocity your entire life. You know how friction and torque and other forces operate in the real world. You may not be used to seeing it in an illustration and thinking about how the forces interact, but you have a lifetime of experience with it. You know that if you set a ball on a hill, it

will roll down. So, use your real-world knowledge of how forces act on objects in order to think through the questions.

Next, let's think about acceleration. We define acceleration as a change in velocity. Remember that velocity is the measurement of speed in a certain direction. So, since acceleration is a change in velocity, acceleration is a change in speed, in direction, or in both. Be aware that in normal conversation, people sometimes use the word "acceleration" a bit differently—they only focus on an increase in speed. But acceleration in science can be an increase or a decrease, and it can refer to speed or direction or both. Imagine that you were riding a bicycle. You go around a curve in the road. Your speed does not change at all when this happens. In scientific terms, this is a change in acceleration because you have changed your direction, even though the speed has remained the same.

Next, let's consider momentum. In science, the word momentum refers to the amount of motion that an object has. The formula for determining momentum is mass times velocity. In other words, the heavier an object is, the more momentum it has. And the faster it is moving, the more momentum it has. Even if you were not familiar with this equation, you probably already understood this idea, since you know that a car moving at sixty miles per hour is harder to stop than a car moving at ten miles per hour, and a large truck is harder to stop than a compact car. Again, as you take the ASVAB, use the real-world knowledge that you have about how objects act in order to help you think about the questions.

We use the word "equilibrium" to describe the state of an object when all forces affecting it are balanced. Another way to say this is that the sum of the forces acting on that object must be equal to zero. In other words, it is not accelerating or experiencing torque.

Next, let's think about fluids and their properties. The first important thing to know is that, in scientific terms, the word "fluid" refers to liquids and gases. This is a bit different from how the word is commonly used. A fluid refers to anything that continually changes its shape, or flows, so that is a category that includes both liquids and gases. Because the particles that make up a fluid are constantly in motion, they exert pressure, which is equal in all directions. Think about

filling up a balloon. The balloon will fill up evenly. It just doesn't happen that one side of the balloon will fill up while the other stays empty. This is because the air that you use to fill the balloon is exerting pressure that is equal in all directions. The particles will always move from an area of higher pressure to an area of lower pressure. We can define pressure as the amount of force in a given area. The equation that describes this is pressure equals force divided by area. This means that if you take a certain amount of force and apply it to a smaller area, the pressure will be greater. Again, you might not be used to thinking in these terms, but it makes sense based on your experience in the world. If you had two tanks of helium and you used one tank to fill a small balloon and the other tank to fill a large balloon, you know that the smaller balloon would be under greater pressure because there would be less space in it for the same amount of helium. There are two factors that impact the pressure of fluids. They are density and depth. The denser a fluid is, the more pressure that it exerts. Also, there is more pressure the deeper down you go into a fluid. Again, this makes sense because all of the fluid above that point is creating more pressure. This means that if you were to go up higher into Earth's atmosphere, the pressure would be lower.

Pascal's Law states that if you change the pressure at any location in a fluid that is in an enclosed space, the change in pressure transmits equally through the fluid. This can be a little difficult to understand in the abstract, but you are already familiar with how it works in the real world. Think about a brand-new tube of toothpaste. The toothpaste is a fluid, since it can flow and change its shape. It meets the requirement of Pascal's Law because it is in an enclosed space. We can change the pressure on the toothpaste by pressing down on it in the middle. What Pascal's Law tells us is that the pressure change is transmitted to the entire tube. It doesn't just stay in the location where you pressed. But you already knew that. If you open the tube and you pressed down on the middle of the tube, the toothpaste would come out of the hole because the pressure increase does not just affect the area where you pressed down, but it affects the entire tube of toothpaste. That's Pascal's Law at work. If Pascal's Law didn't hold, you would be able to press on the middle of the tube without any toothpaste coming out of the end. The fact that fluids transmit pressure is a principle that is applied to many different situations and can be quite useful—not just for brushing your teeth.

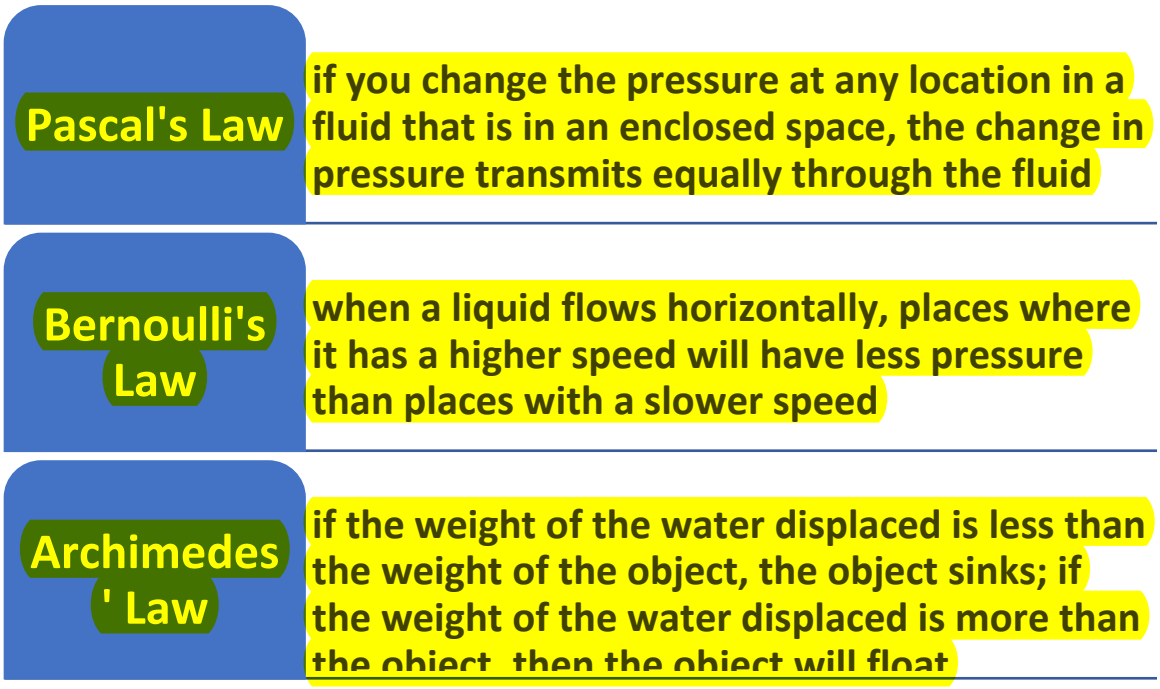
Bernoulli's Law tells us how fluids behave as they flow up and down. The tricky thing about it is that it can seem counterintuitive. In other words, this is an instance where your experience with the real world might lead you to reach the wrong conclusion. Bernoulli's Law states that when a liquid flows horizontally, places where it has a higher speed will have less pressure than places with a slower speed. So imagine a water pipe that is horizontal. Water is flowing through it. At a certain point, the diameter of the pipe changes. When the water moves faster, it is under less pressure, and when the water moves more slowly, it is under greater pressure. This can be confusing, because if you imagine two hoses, you might think of the one with greater pressure as having water that moves more quickly. But it is still true that pressure is lower when the fluid is faster. In fact, it is this principle that allows birds and airplanes to fly, despite the fact that they are, obviously, much heavier than air. Here is how it works: Because of how the wings are shaped, air beneath the wing flows more slowly than the air above the wing. And Bernoulli's Law tells us that higher speed means less pressure, which means that the air above the wing has less pressure than the air beneath the wing. Since that is the case, the bird or the plane is able to lift above the ground. This is the same principle at work in using a spoiler on the back of a car. You can think of a spoiler as the opposite of a wing: it pushes the car down by causing the pressure above the spoiler to push the car toward the ground. The goal is to increase friction so that the car does not leave the track or road.

The word "buoyancy" refers to the upward pressure that is exerted on any object placed in a fluid. In other words, buoyancy means that objects tend to float in a fluid. If you have ever floated in a pool, you have taken advantage of the principle of buoyancy. Why does this happen? Remember that in fluids, pressure increases as depth increases. So if you imagine an object in a body of water, there is more pressure on the bottom of the object than on the top of the object since the pressure increases with depth. This means that many objects will float because of this difference in pressure. Of course, not everything will float. Whether an object will sink or float depends on its density, which can be calculated as its mass divided by its volume. Again, you already know this intuitively, even if you haven't ever thought about it in scientific terms. You know that if you took a rock into a swimming pool, the rock would sink because it is very dense. But if you took an inflatable beach ball, the ball would float. And you

probably know that even if the rock and the beach ball had the same mass, the ball will float and the rock will not because the beach ball has a much greater volume. Still, you might wonder how something like a huge cruise ship can float, given how much it weighs, even though its size is large. Whether a large ship will float depends on how much water it displaces. Have you ever gotten into a bath tub or hot tub and noticed that the water level rose? This is called displacement, and it happens because your body and the water can't be in the same place at the same time. So, if your body is going to be in the hot tub, the water can't be in the same place. It moves up; this is called displacement. Archimedes' Law states that if the weight of the water displaced is less than the weight of the object, the object sinks. But if the weight of the water displaced is more than the object, then the object will float. Imagine that you had two identical lumps of clay. You shape one into a ball and you shape the other into a boat. The ball sinks and the boat floats. Why? Because the shape of the ball means that it does not displace much water, it sinks. On the other hand, the shape of the boat leads it to displace a lot of water, so it floats. The weight of the displaced water is greater than the weight of the clay boat, so, according to Archimedes' Law, the boat will float. Have you ever noticed that if you spread out your arms and legs, you are more likely to float than if you curl up into a ball? This is the same principle at work as with the lump of clay. Your body displaces more water when you spread out, so you float better.

See Figure Twenty-Three for a summary of the three principles related to fluid that we have reviewed:

FIGURE TWENTY-THREE: LAWS RELATED TO LIQUIDS



Think about a drop of rain. Have you ever wondered why it forms a rounded shape instead of being completely flat? This is because of surface tension. When molecules are strongly attracted to each other on the surface of a liquid, we say that that liquid has a high surface tension. This is why the surface of a small amount of water can take on a rounded shape. This is an example of cohesion, which is the term used for the tendency of molecules to be attracted to other molecules of the same kind. If the water were sticking to another kind of molecule, that would be an example of adhesion.

Let's turn to some other properties of materials. Have you ever been bungee jumping? If so, you have taken advantage of the property of elasticity. This property refers to the ability of an object to return to its original shape after being compressed or stretched. An elastic material will exert a force in the opposite direction when it is stretched or compressed, and this is called the elastic force. This is what allows it to return to its original shape.

Other properties of materials include weight, strength, density, and thermal properties. The unique combinations of properties are what determines which material is best in which

situation. We have already discussed density and how that impacts whether an object will sink or float. Thermal properties refer to how an object reacts when heat is applied to it. Thermal conductivity refers to how well a material conducts heat. In some situations, you might want a material that is good at conducting heat. For example, people bake with metal pans when they want heat to be conducted. Of course, in other situations, you do not want heat to be conducted easily. This is why you use a hot pad when you take the metal pan out of the oven: you do not want the heat from the pan to be conducted into your hand because it will burn you, so you use the hot pad, which will not conduct the heat from the pad to your hand.

Gravity refers to the force of attraction between two objects. Notice how this definition is a bit different from how the word is commonly used. Gravity is not just the force that makes a ball hit the ground when you drop it. Rather, gravity is a force of attraction between the ball and the Earth. The ball is actually exerting some gravitational attraction on the Earth. However, the smaller an object is, the less gravity it is exerting on another object, so the ball is exerting a very small gravitational force. While gravity can act even when two objects are not touching, the force decreases the father apart objects are from each other. Each object has a center of gravity. This is the point where the body would be at equilibrium if it were supported at this point. Imagine that you had a ruler. If you placed one finger under the three-inch mark, the ruler would fall to the ground. But if you placed one finger under the six-inch mark, the ruler would balance on your finger because that is the center of gravity of the ruler. A ruler is a very simple object, and it is easy to understand that the center of gravity would be right in the middle of it. An object's center of gravity can actually be located outside of the object, although this is pretty rare.

The mechanical comprehension section of the ASVAB is somewhat unusual in that, on the one hand, it involves some pretty advanced scientific concepts, but, on the other hand, it involves principles that you see in daily life, even if you are not familiar with the terms used to describe them. The material that has been presented in this section reviewed the most important of these ideas. When you are answering the questions on this section of the test, remember to

think about what you know from experience to be true of the physical world. Try to apply that knowledge to the problems that you encounter on this section.

Key Take-Aways

One. Work equals force times distance.

Two. Power equals work divided by time.

Three. A machine is a mechanical device that applies a force. The six simple machines are an inclined plane, a lever, a wedge, a screw, a pulley, and a wheel and axle.

Four. Newton's first law states that whether something is at rest or in motion, it will tend to stay that way unless an outside force acts on it. Newton's second states that acceleration is proportional to the force applied to the object, and it is inversely proportional to the mass of the object. The third law of motion states that for every action, there is an equal and opposite reaction.

Five. Friction is the force that resists motion.

Six. Torque is the force that causes an object to rotate.

Seven. Velocity takes the direction of motion into account and speed does not.

Eight. Acceleration is the change in velocity.

Nine. Momentum refers to the amount of motion that an object has. The formula for determining momentum is mass times velocity.

Ten. The word "fluid" refers to liquids and gases.

Eleven. Pressure equals force divided by area.

Twelve. Pascal's Law states that if you change the pressure at any location in a fluid that is in an enclosed space, the change in pressure transmits equally through the fluid.

Thirteen. Bernoulli's Law states that when a liquid flows horizontally, places where it has a higher speed will have less pressure than places with a slower speed.

Fourteen. “Buoyancy” refers to the upward pressure that is exerted on any object placed in a fluid.

Fifteen. Archimedes’ Law states that if the weight of the water displaced is less than the weight of the object, the object sinks. But if the weight of the water displaced is more than the object, then the object will float.

Sixteen. Elasticity refers to the ability of an object to return to its original shape after being compressed or stretched.

Seventeen. Gravity refers to the force of attraction between two objects.

Eighteen. Use your knowledge of how materials behave in the real world to help you answer questions on this section.

QUIZ

1. What is the purpose of a wing on an airplane?

A. to increase the speed of the plane

B. to change the air pressure

C. to reduce friction

D. to create a simple machine

Answer: B. An airplane is able to fly because of Bernoulli's Law, which states that when a liquid flows horizontally, places where it has a higher speed will have less pressure than places with a slower speed. The shape of a wing creates a difference in pressure that provides lift to a plane or a bird.

2. What is the advantage in using a pulley?

A. it increase friction

B. it adds energy

C. it changes the direction of the force applied

D. it adds to the center of gravity

Answer: C. The advantage of using a pulley is that it changes the direction in which the force needs to be applied to move an object. Think about a well. There is a bucket at the top, and the bucket is connected to a pulley with a rope. To pull up the bucket, you pull down on the rope. For most people, this is much easier to do. This is why a pulley can be useful.

3. **When a rubber band returns to its original shape after being stretcheded, this is an example of what?**

A. buoyancy

B. elastic force

C. friction

D. velocity

Answer: B. The elastic force describes the ability of objects to retain their original shape after they have been stretched or compressed.

4. **Which force is responsible for the fact that it is more difficult to push a rock across an uneven lawn than across a smooth driveway?**

A. gravity

B. buoyancy

C. elasticity

D. friction

Answer: D. Friction is the force that resists movement between two objects. A lawn will have more friction than a driveway when the lawn's surface is uneven, because it will have more friction.

5. **Which one of these is a measurement of velocity?**

A. one hundred miles an hour to the southwest

B. one hundred miles per hour

C. to the southwest

D. hours

Answer: A. Velocity is a measurement of speed and direction. Only option A provides both of those elements, so it is the correct answer.

6. Which of these will make a raft more likely to float?

A. making it out of a denser material

B. increasing the amount of water

C. decreasing the dimensions of the raft

D. increasing the dimensions of the raft

Answer: D. Floating is more likely to occur when an object is less dense. Density is equal to mass divided by volume, so increasing the volume of the raft makes it less dense and therefore more likely to float.

7. Which one of these is NOT an example of acceleration?

A. a car driving around a curve

B. a car slowing down

C. a car speeding up

D. a stopped car

Answer: D. Acceleration is a change in velocity. Remember that velocity includes both speed and direction, so a car changing direction, as in option A, is experiencing a change in acceleration. This means that option D is the correct answer, since it is the only situation where the car's direction and speed are not changing.

8. A child presses on a juice pouch and the juice squirts through the straw. Which principle has been illustrated by this action?

A. buoyancy

B. elasticity

C. torque

D. Pascal's Law

Answer: D. Pascal's law states that a pressure change anywhere in a fluid that is in an enclosed space is transmitted throughout the entire fluid.

9. Which of these is NOT a simple machine?

A. an inclined plane

B. a circuit

C. a lever

D. a wedge

Answer: B. The six simple machines are an inclined plane, a lever, a wedge, a screw, a pulley, and a wheel and axle.

10. A glass placed too close to the edge of the table falls to the floor. If you were to describe what happened in scientific terms, which of these phrases would you be most likely to use?

A. center of gravity

B. decreased friction

C. torque force

D. wheel and axle

Answer: A. Each object has a center of gravity, which is the point where the body would be at equilibrium if it were supported at this point. Because the glass's center of gravity was off the edge of the table, the glass fell.

ASSEMBLING OBJECTS (AO)

If you take the ASVAB on a computer, you will have forty minutes to answer thirty questions in this section. If you take the paper version of the test, you will have fifteen minutes to answer twenty-five questions.

This section of the ASVAB is testing your ability to visualize how objects will look if their location is changed. For example, one of the practice questions on the official ASVAB site has a half circle, a triangle, and a line. One point on the half circle is labelled with the letter A, and one point on the triangle is labelled with the letter B. The ends of the line are labelled A and B. The questions asks you what the picture will look like if you connect the two points labelled A to each other and you connect the two points labelled B to each other. The four answer choices show the half circle, triangle, and line in various relationships to each other, with no points labelled. To answer the question correctly, you need to choose the answer option that shows the arrangement of objects if the A's were touching each other and the B's were touching each other. The second question shows a circle that has been divided into four irregular shapes. The answer options each show a circle divided into various shapes. You are supposed to select the circle that is made out of the four shapes in the first panel. As you can see, what this section is testing is your ability to assemble an object from the parts that are given to you on the test. The parts will be shapes, and your job will be to find the answer choices that shows the shapes arranged in the way that the problem is asking for them to be arranged.

Before you spend too much time thinking about a problem in this section, you need to look quickly at the answer choices. In the sample problem with the circle, if you only looked at the four pieces in the problem but you did not look at the answer choices, it may not have been obvious that they should form a circle. If you were only studying the problem without looking at the answers, you may have tried to assemble those shapes to form a triangle or a rectangle. This would have wasted a lot of time and energy. But if you took a look at the answer choices, it would be obvious that the pieces needed to be moved around to assemble a circle, since all of the answer choices were circles. This is an important clue that would help you solve the problem much more easily and quickly. So, before you do anything else, look quickly at the

answer choices. This will normally limit the possible shapes that the pieces can be assembled to form.

Your strategy for this section should consist of three steps: number, shape, location. You should probably memorize that list so that you can recall it on the test. Remember: number, shape, location. Let's cover what each step means.

The first step is number. This refers to the number of shapes. You should check the answer choices and determine if they have the correct number of shapes. For example, in the practice problem with the circles, you were supposed to re-assemble the four pieces in the problem to form a circle. But one of the answer choices had a circle made out of three shapes, so you could eliminate this choice very quickly, and you could do it even if you are not very good at visualizing objects. All this step requires is simple counting. So, the first step to answering an assembling objects question is to count the number of shapes in the problem and eliminate any answer choices that have a different number of shapes.

The second step is shape. This means that the shapes in the correct answer have to have the same shapes as the shapes in the problem. Here's how to do this step: find one unusual or obvious shape in the sample problem and then test the answers to see if it has the same shape. In the online sample question with the circle, one of the pieces is a long, skinny segment of a circle. You can test each answer choice to see if it has that same long, skinny shape. It's clear that option A does not, so you can eliminate this answer choice. Then, you can select another shape from the sample problem and see if that shape can be found in the answer choices. Continue this process, and you should be able to eliminate several of the answer choices. Be aware that it is possible for the shape to be turned in the answer choice, so it might be facing a different direction in the answer than it is in the problem. So you will probably need to mentally rotate the shapes as you test them to see if they are found in the answer choices. For many problems, you will be able to find the correct answer using only these two steps of the process.

The third step is location. In this step, you are checking to see if the arrangement of the shapes is correct. In the same problem with the line labelled with A and B, the letter A was on one

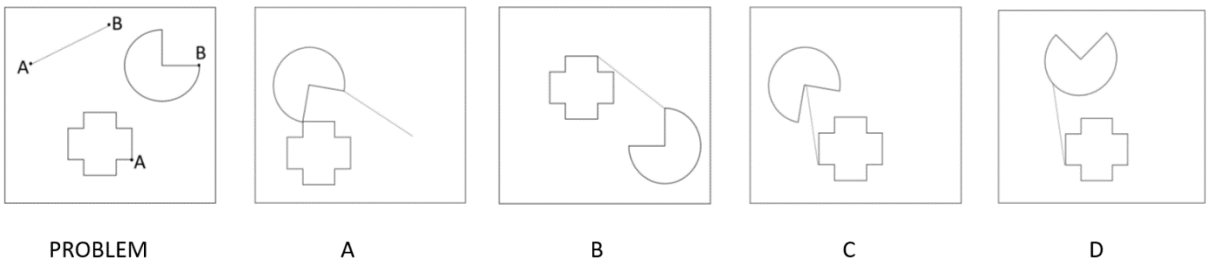
corner of the triangle in the problem. This means that in the correct answer, the letter A has to be on a corner of the triangle. You can look at the answers and eliminate any choices where the letter A is not attached to the corner of the triangle. This would eliminate half of the answer choices.

In general, it is quite easy to do well on this section if you approach each problem with a plan and carefully check the options. But some students decide not to be systematic about the answer choices and instead to just "eyeball" the answer options and choose the one that their gut tells them is best. This is not a good strategy. It is too easy to miss something that makes an answer incorrect if you do this. Instead, follow the strategy in this section, which will ensure that you think about each problem methodically and eliminate the answer choices that cannot possibly be correct. When you do this, you will be left with the correct answer.

It is true that some people have a better ability to visualize objects than other people do. If you feel that you are particularly weak in this area, you can develop your skill by doing jigsaw puzzles or little games on your phone that require you to rotate objects in space and fit them together. This can help you develop the ability to visualize and mentally rotate objects so that you can do your best on this section of the test.

Let's work through two sample questions to practice the process for answering the assembling objects questions. See Figure Twenty-Four.

Figure Twenty-Four: Assembling Objects Sample Question One

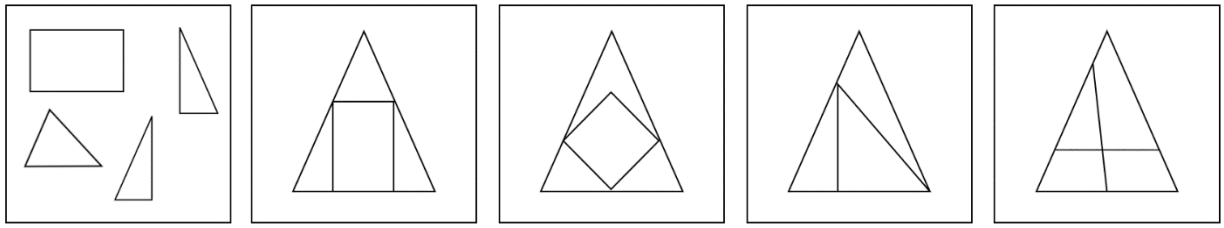


This problem asks for you to select the answer choice that shows best how the objects will be arranged if the letters in the problem are matched. Remember that our first step is to quickly scan the answer choices to get a sense of what our options are. So that should be the first thing that you do in approaching this question. When you do that, you see that your answer choices consist of the line, the partial circle, and the plus shape arranged in different ways. Then, remember that our three-step process is number, shape, location. In this problem, the number of pieces is the same in the problem as it is in the answer choices, so we aren't able to eliminate any answer choices at this point. The second step is shape. In this problem, we have the same shapes in the problem as in the answer choices, so we still can't eliminate anything. That leaves us with the third step, which is location. Notice that, in the problem, the letter B is attached to the outside edge of the circle shape. This means that, in the correct answer, the line will have to be touching that point on the circle. That is true for option A, and it is true for option B, but take a closer look at option C. In option C, the line is touching the center point of the circle, not the edge of the circle. This means that we can eliminate option C; it cannot be the correct answer. Now look at option D. There, the line is touching the edge of the circle, but it is in the middle of the arc of the circle, not at the point where the circle shape changes to a line segment. This means that option D cannot be the correct answer. Next, take a look at the problem again. In the problem, the letter A is touching the plus shape at an exterior corner. That means that in the correct answer, the line will have to touch the plus shape at an exterior corner. But now look at answer option A. In that figure, the line isn't touching the plus shape at all. So it cannot be the correct answer. Now, we have eliminated all of the answer choices except for option B. If you have enough time, you can test each element of option B by mentally rotating the three pieces in the problem to see if they can in fact form the arrangement in option B. They can, so we know that this is the correct answer.

Again, these problems are not that difficult if you approach them methodically and take it step by step. Test takers tend to do well on these problems if they use that approach. They tend to get into trouble if they just go with their hunch or their intuition. So remember, always follow the steps and be careful.

Now, take a look at Figure Twenty-Five.

Figure Twenty-Five: Assembling Objects Sample Question



Let's work through this problem. Remember, the first thing to do is to take a quick look at the answer options for clues about what shape we are looking for. Well, when you do that, it is pretty obvious: the four shapes in the problem need to be joined together so that they form a triangle. You can see how important this step is: if you hadn't taken the time to look at the answer options, you might have thought that you needed to form the four shapes in the problem into another shape, and you would have wasted a lot of time. Now that we know that we are aiming for a triangle shape, we can use the three steps of our method to find the solution. Remember that those steps are number, shape, and location. The first step is number. This means that the correct answer choice has to have the same number of pieces as the problem. Since the problem has four pieces, this means that the correct answer has to have four pieces. Option A has four pieces, and option B has four pieces. But take a look at option C. It is composed of only three pieces, so we know that it cannot possibly be the correct answer, and we can eliminate it. Option D has four pieces, so it is a possibility. The second step is shape. In the problem, we have a rectangle and three triangles. This means that the correct answer choice must have those same shapes. Let's test this by starting with the triangle that is on the bottom left. Let's test our answer choices to see if that shape is in them. Look at option A. Your first instinct might be to say that you cannot find that triangle shape in option A but remember that it is possible that the shapes are rotated. If you rotate the triangle in the problem, it looks like the triangle that forms the top on Option A. So we cannot eliminate option A. This is a very important point, and the cause of many incorrect answers on this section of the ASVAB. So you

must remember that it is possible that the shapes in the problem will be rotated in the answer choices. This does not make the answer choice wrong. Next, take a look at option B. It looks like our triangle is about the same shape as the triangles that form the corners of this triangle. So we would not want to eliminate it yet. We don't need to think about option C anymore; we have already eliminated it since it did not have the correct number of shapes. Next, take a look at option D. Our triangle is somewhat similar to the triangle in the upper left corner. It seems like the angles might be a bit off, but sometimes it can be hard to tell exactly. We should be suspicious of this option, but we may not want to completely eliminate it at this point. Now, let's return to the problem. Notice that the two other triangles in the problem appear to be the same size and shape; it is just that one is the mirror image of the other one. We should check out the answer choices and see which ones have these two mirror image triangles in them. We can eliminate any options that don't have them. When we do this, it becomes pretty clear that option A is the only possible answer. But, just for the sake of practice, let's imagine that you were not able to eliminate all of the other answer choices at this point. In that case, we would use the third step of our process for solving these problems, which is location. We don't need it for this problem, but it is very useful on other problems, especially the ones with the labelled points. So don't forget to use that step when you need it. Again, if you follow these steps, these problems are fairly straightforward and should give you little trouble. It's only when test takers are not willing to go through all of the steps of the process that they end up getting into some trouble by going with a hunch or what looks right. Remember, always work through the steps of the process so that you can reach the correct answer.

Key Take-Aways

One. This section tests your ability to move, rotate, and arrange shapes in your head.

Two. Before you work on the problem, take a look at all of your answer choices.

Three. The first step to answering these questions is to check the number of shapes in the answer choice and be sure that it matches the number of shapes in the problem.

Four. The second step is to test each shape in the problem and be sure that it matches the shapes in the answer choice.

Five. The third step is to check the location of the shapes. Be sure the answer matches the problem.

Six. Approach each problem using the three steps (number, shape, location). Do not go by a hunch or instinct.

QUIZ

1. Which of these activities would best help you prepare for the assembling objects section of the ASVAB?

A. practicing algebra problems

B. learning the names of geometric concepts

C. doing puzzles

D. drawing shapes

Answer: C. Since this section tests your ability to mentally arrange shapes, the best way to practice of the options stated is to do puzzles. This can help you develop your skills in mentally moving and placing shapes into the correct location.

2. Before you begin work on the problem, what should you do?

A. draw the shapes on scratch paper

B. use the mouse to move the shapes

C. measure the lengths with a ruler

D. look at the answer choices

Answer: D. The answer choices limit the possible ways that the shapes can be arranged and will give you important clues about how the problem should be solved. So be sure to take a look at the answer choices before you begin thinking about how to rearrange the shapes.

3. Which of these statements is true about the number of pieces?

A. the answer must have the same number of pieces as the problem

B. there is no relationship between the number of pieces in the problem and solution

C. there may be more pieces in the answer than in the problem

D. there may be fewer pieces in the answer than in the problem

Answer: A. Because the answer involves moving and arranging the pieces in the problem, there will always be the same number of pieces in the correct answer as in the problem. This is why it is important to check the number of pieces in the answer choice against the number of pieces in the problem as the first step in solving the problem. These numbers need to be the same. If they are not, you can eliminate the answer choice.

4. **When you are checking the shapes of the pieces in the problem against the shapes of the pieces in the answer choices, which of the following might be true for the correct answer?**

A. the piece might be missing
B. the piece might be present two or more times
C. the piece might have been stretched or compressed
D. the piece might have been rotated

Answer: D. In the correct answer, a piece that was in the problem will not be missing. It will also not be duplicated. And it will not be stretched or compressed but rather it will be the same size and shape as it was in the problem. So, options A, B, and C are not correct. However, it is possible that a shape that was in the problem might be rotated in the answer. This means that option D is correct. It also means that you need to be careful when you are testing for pieces before you decide that a piece is missing. It could be there but rotated, and this makes it a bit more difficult for your brain to identify it as the same piece. Be sure to mentally rotate the pieces before you decide that one is missing.

5. **Which of the following should you NOT do when answering assembling objects questions?**

A. go with a hunch about what looks right
B. count the number of pieces in the answer choice
C. compare the shapes of the pieces in the answer choice

D. compare the location of the pieces in the answer choice

Answer: A. Often, a hunch about what is right will lead to an incorrect answer. It is a much better strategy to simply follow the steps of checking the various aspects of the problem—number, shape, and location—in order to find the correct answer.

6. What is the assembling objects test trying to measure?

A. knowledge of shape names
B. algebra skills
C. ability to visualize spatial relationships
D. creativity

Answer: C. This section is testing your ability to visualize spatial relationships. It is important to know that, especially in relation to option D: the goal is not to be creative but to see how the shapes have been moved. You do not need to know algebra or the names of the shapes to do well on this section of the ASVAB.

7. Which of the following would be the incorrect answer to a question that asked you to match the location of two points that were both labelled A?

A. an answer choice where one of the objects was rotated
B. an answer choice where the first point A was in the same place as the second point A
C. an answer choice point A had changed its location relative to one of the objects
D. an answer choice where both objects were moved to new positions

Answer: C. For an answer choice to be correct, the location of point A on a shape must be the same location as point A was in the problem. Now, it is possible that the entire object will be moved to a different part of the box. It is also possible that the entire object will be rotated. But point A has to be on the same location of the object in both the problem and the solution. For example, if the object is a square and point A is on the corner of the square in the problem, point A also has to be on the corner of the square in the solution. Point A can't move to the middle of the square, and it can't be in the

middle of one of the sides of the square. It has to remain on the corner of the square in the answer if that is where it was in the problem.

8. **Which of the following would be the correct answer to a question that asked you to match a line with ends labelled A and B to a triangle with a corner labelled B and to another triangle with a corner labelled A?**

A. the line linked to a corner of each triangle

B. the two triangles touching each other and the line off to the side

C. the line linked to the center of each triangle

D. the line linked to the middle of a side of each triangle

Answer: A. Remember, in the problems where you are given points that are labelled with letters or numbers, the correct answer will show two points with the same label placed so that they would be on top of each other. This is why option A is correct: it is the only option that permits that to happen.

9. **Which of these is the best real-world comparison to the assembling objects questions?**

A. building an engine

B. giving a speech

C. solving a math problem

D. doing a jigsaw puzzle

Answer: D. The questions on the assembling objects section ask you to mentally move around shapes so that they are arranged in a particular pattern. This is most like doing a jigsaw puzzle. Sometimes the name “assembling objects” is confusing to people because they think that it means that they will be assembling physical objects, such as an engine. But this section is more like doing a puzzle. This fact also suggests one important rule that can protect you from incorrect answers on this section: it is generally not acceptable to mentally flip over a piece. You can slide it around and you can rotate it,

but you can’t flip it over. This is just like with a jigsaw puzzle: you can’t turn the pieces over to fit them in, but you can slide them around and rotate them.

10. Which of the following can be true of a correct answer on the assembling objects section?

A. a triangle might be stretched out compared with the triangle in the problem

B. there might be three copies of one square that was in the problem

C. a hexagon might be rotated

D. a triangle might be the mirror image of the triangle in the problem

Answer: C. It is acceptable to rotate the pieces. However, it is not acceptable to stretch them, have multiple copies of them, or have mirror images of them.

PRACTICE TEST

1. **A rock that is formed when small particles, such as sand, pebbles, shells, and other bits of material, join together and hardens into a rock forms what type of rock?**

   A. igneous

   B. elementary

   C. sedimentary

   D. metamorphic

   Answer: C. A sedimentary rock forms when small particles, such as sand, pebbles, shells, and other bits of material, joins together and hardens into a rock

2. **One thousand meters is equivalent to how many kilometers?**

   A. one

   B. ten

   C. one hundred

   D. ten thousand

   Answer: A. There are one thousand meters in one kilometer, so option A is correct.

3. **The lungs are part of which system of the human body?**

   A. nervous

   B. respiratory

   C. immune

   D. skeletal

   Answer: B. The lungs are part of the respiratory system.

4. **Which term describes an animal that eats both mice and ferns?**

A. omnivore

B. carnivore

C. aptivore

D. herbivore

Answer: A. Omnivore is the term used to describe an animal that eats both plants and animals.

5. **A chart that shows how energy moves through an ecosystem in terms of which animals consume other animals and/or plants would be an example of which of the following?**

A. rock cycle

B. food web

C. solar cycle

D. water cycle

Answer: B. A food web shows how energy flows through an ecosystem by showing which animals consume other animals or plants.

6. **What is the basic building block of all substances?**

A. cells

B. atoms

C. compounds

D. mixtures

Answer: B. Atoms are the basic building block of all substances. (Cells are only found in living things, but everything is made of atoms.)

7. In physics, what the definition of work?

A. activity that is paid

B. activity that is physical in nature

C. using force to move an object

D. activity that causes a chemical change

Answer: C. In science, work has a specific meaning: it refers to using force to move an object.

8. The classification system which includes the animal kingdom is a way of organizing what?

A. all animals

B. all living things

C. all atoms

D. all forms of work

Answer: B. The classification system, with its kingdoms, organizes all living things.

9. Which biome is a woodland with widely-spaced trees?

A. desert

B. mountains

C. savanna

D. tundra

Answer: C. The definition of a savanna is that it is the biome which is a woodland characterized by widely-spaced trees.

10. The sun is what kind of object?

A. planet

B. galaxy

C. star

D. comet

Answer: C. The sun is a star.

11. Which of the following is not one of the major nutrients that humans need?

A. carbohydrates

B. fats

C. proteins

D. bacteria

Answer: D. The three major nutrients that humans require are carbohydrates, fats, and proteins.

12. Lamar's world history test grades are eighty-two, ninety-four, seventy-nine, eighty-seven, and ninety-one. What is the average of his test grades, rounded to the nearest whole number?

A. eighty-four

B. eighty-six

C. eighty-seven

D. eighty-nine

Answer: C. To get an average, we add up all of the numbers and then divide them by the number of numbers. When we add these five numbers together, we get four hundred and thirty-three. When we divide that number by five, we get eighty-six point six. The question asks us to round the answer. That number rounds up to eighty-seven, so option C is the correct answer.

13. If a horse can run one lap around a race track in seven minutes, how long will it take the horse to run six laps? (Assume the horse runs each lap at the same speed.)

A. six

B. seven

C. thirty

D. forty-two

Answer: D. To solve this problem, we need to multiply seven times six since it takes seven minutes for each lap, and since the horse runs six laps. The answer to that is forty-two.

14. Jim is putting new tile in his kitchen. The kitchen is a rectangle that is fourteen feet by twelve feet. If each tile is one square foot, how many tiles will Jim need?

A. one hundred

B. one hundred and sixty-eight

C. two hundred

D. two hundred and sixty-eight

Answer: B. To solve this problem, we need to find the area of the kitchen floor. Since it is a rectangle, we can multiply the length times the width. Fourteen times twelve equals one hundred and sixty-eight, so that is the correct answer to this problem.

15. Nathan and Simon are bicycling along the same road. Nathan started from the north and is travelling south, while Simon started from the south and is travelling north. They both started cycling at seven in the morning. Nathan cycles at ten miles per hour. Simon cycles at eight miles per hour. If they began one hundred miles apart, how far apart will they be at ten in the morning?

A. eighteen

B. thirty

C. forty

D. forty-six

Answer: D. Since Nathan moves at ten miles per hour, after three hours he has moved thirty miles. Since Simon cycles at eight miles per hour, after three hours, he has moved twenty-four miles. They were one hundred miles apart at the beginning, but Nathan's cycling reduced that distance by thirty miles and Simon's cycling reduced that distance by twenty-four miles. This means that they were forty-six miles apart at the end.

16. Greg bought a new phone on credit. The phone cost six hundred dollars. He had to make a down payment of one hundred dollars when he picked up the phone. The next month, he paid twenty percent of the phone's original cost. If he wants to pay off the phone over the next five months, how much will he need to pay each month?

A. seventy dollars

B. seventy-six dollars

C. one hundred dollars

D. one hundred and twenty dollars

Answer: B. The initial price of the phone is six hundred dollars. Greg makes a one hundred dollar down payment, so now he owes five hundred dollars. The next month, he pays twenty percent of the phone's original cost, which is equal to one hundred and twenty dollars. This means that he now owed three hundred and eighty dollars. Divide that number by five, and the answer is seventy-six.

17. A cookie recipe calls for three-quarters of a cup of sugar and makes one dozen cookies. If a baker wants to make eighty-four cookies, how much sugar will they need?

A. three-quarters of a cup

B. three cups

C. four cups

D. five and one-quarter cups

Answer: D. To make eighty-four cookies, the baker will need to multiply the original recipe by seven. Seven times three-quarters equals five and one quarter, so option D is the correct answer.

18. Sofia worked for eight hours and earned eighty-four dollars. How long will she need to work to earn five hundred and sixty-seven dollars?

A. forty-four hours

B. fifty hours

C. fifty-four hours

D. sixty hours

Answer: C. Sofia is earning ten dollars and fifty cents per hour if she worked for eight hours and earned eighty-four dollars. If we divide five hundred and sixty-seven by ten dollars and fifty cents, we discover that she will need to work for fifty-four hours to earn that amount of money.

19. Kim painted one-third of her bedroom on Thursday. On Friday, she painted two-fifths of it. How much of the bedroom still needs to be painted?

A. three-fifteenths

B. four-fifteenths

C. eleven-fifteenths

D. twelve-fifteenths

Answer: B. To solve this problem, begin by adding the fractions. Remember that the denominators need to be the same when you add fractions. This results in eleven-fifteenths. But the problem asked for how much of the bedroom still needs to be painted, not how much has to be painted. If eleven-fifteenths of the bedroom has already been painted, this means that four-fifteenths still need to be painted.

20. Hector went shopping. He started with seventy-six dollars. He bought a new phone case for sixteen dollars. Then he ran into a friend who paid Hector back the twenty-three dollars that he had borrowed from him. Hector spent eleven dollars on lunch and then bought new shoes for forty-six dollars. How much money did Hector have at the end of the day?

A. twenty-six dollars

B. sixty dollars

C. seventy-two dollars

D. eighty-three dollars

Answer: A. To solve this problem correctly, you will need to take account of each expense as well as adding in the money that was repaid to Hector. You will need to pay close attention to the positive and negative numbers. The problem should look like this: seventy-six minus sixteen equals sixty. Sixty plus twenty-three equals eighty-three. Eighty-three minus eleven equals seventy-two. Seventy-two minus forty-six equals twenty-six.

21. Helen is trying to determine if a store has charged her the correct amount for a new laptop. The original price of the laptop was nine hundred and thirty dollars. It was on sale for twenty-percent off. There was a rebate of fifty dollars. How much should the store have charged her for the laptop?

A. six hundred and twelve dollars

B. six hundred and ninety-four dollars

C. seven hundred and forty-four dollars

D. nine hundred and thirty dollars

Answer: B. To solve this problem, begin by figuring out the sale price of the laptop. The easiest way to do that is to multiply the original cost of the laptop by point eight. The reason that you do this is that the laptop is twenty percent off, which means that it costs eighty percent of its original price. When you convert eighty percent to a decimal,

you get point eight. So nine hundred and thirty times point eight equals seven hundred and forty-four. Then, subtract the fifty-dollar rebate, and the result is six hundred and ninety-four dollars.

22. A factory has eight hundred boxes that need to be shipped out before the end of the day. If there are twenty employees, how many boxes will each employee need to prepare?

A. twenty

B. forty

C. sixty

D. eighty

Answer: B. This is a simple division problem. Eight hundred divided by twenty equals forty, so option B is the correct answer.

23. What is the area of a triangle if its base is eighteen meters and its height is twelve meters?

A. fifteen meters

B. thirty meters

C. one hundred and eight meters

D. two hundred and sixteen meters

Answer: C. To find the area of a triangle, you multiply its base times its height and then you divide that product by two. Eighteen times twelve equals two hundred and sixteen, and that number divided by two equals one hundred and eight.

24. Which of the following statements is NOT true of an equilateral triangle?

A. all of the sides are the same length

B. all of the angles have the same measurement

C. all of the angles are equal to sixty degrees each

D. all of the angles are equal to ninety degrees each

Answer: D. In an equilateral triangle, all of the sides are the same length. All of the angles have the same measurement, and that measurement is sixty degrees.

25. Which word describes two lines that cross each other and form a ninety-degree angle where they do so?

A. parallel

B. perpendicular

C. equilateral

D. obtuse

Answer: B. Two lines are perpendicular if they intersect at right angles.

26. What is the area of a circle whose diameter is ten inches?

A. fifteen point seven

B. seventy-eight point five

C. ninety-two

D. three hundred and fourteen

Answer: B. Note that this problem provided the diameter, not the radius. Our formula for the area of a circle is that the area is equal to the radius squared times pi. The radius of this circle is five. Five squared is twenty-five. That number times pi, which we will approximate as three point fourteen, equals seventy-eight point five.

27. What is the least common multiple of seven and eight?

A. twenty-four

B. fifty-six

C. ninety-two

D. one hundred

Answer: B. To find the least common multiple, you are looking for the smallest number that is a multiple of both of the numbers that you are given. To solve this problem, you should list out the multiples of seven, starting with fourteen. Then, list the multiples of eight, starting with sixteen. The first number that is on both of these lists is fifty-six, so that is the correct answer to the question.

28. What is four to the fourth power?

A. four

B. sixteen

C. one hundred

D. two hundred and fifty-six

Answer: This problem is asking what the result is when you multiply four times itself four times. If you do that multiplication, the answer is two hundred and fifty-six.

29. What is the square root of eighty-one?

A. eight

B. nine

C. one hundred and sixty-two

D. eight hundred

Answer: B. The square root is the number that you have to multiply by itself in order to get the number that you are given in the problem. In this case, nine times time equals eighty-one, so the answer is nine.

30. Given the equation five x minus three equals thirty-seven, solve for x.

A. thirty-four over five

B. eight

C. fifty-three

D. two hundred

Answer: B. To solve this problem, begin by adding three to each side. This gives you five times x equals forty. Then, divide each side by five. This results in x equals eight.

31. Calvin bought ten books. He had a coupon for twenty dollars off of his purchase, and he paid one hundred and eighty dollars. Which equation represents this situation?

A. ten times b minus twenty equals one hundred and eighty

B. ten plus b minus twenty equals one hundred and eighty

C. twenty times b minus ten equals one hundred and eighty

D. ten times b equals one hundred and eighty minus twenty

Answer: A. We multiple ten times b since Calvin bought ten books. We subtract twenty since he had a twenty-dollar coupon. And we set that expression equal to one hundred and eighty since that is the amount that Calvin paid.

32. Which of these statements describes an angle?

A. two parallel rays

B. two rays that share an endpoint

C. two parallel line segments

D. three intersecting line segments

Answer: B. One definition of an angle is that it is composed of two rays that share an endpoint. If you draw this figure, you will see that you have created an angle.

33. The sides of a triangle are eleven inches, eleven inches, and eight inches. Which term describes this triangle?

A. obtuse

B. scalene

C. isosceles

D. equilateral

Answer: C. Since two sides of the triangle are the same length, we call this an isosceles triangle.

34. Solve this expression: five plus open parentheses three times two minus two close parentheses divided by two.

A. one

B. two and a half

C. seven

D. ten

Answer: C. The trick to this question is to follow the proper order of operations. You begin inside the parentheses, so three times two equals six, and six minus two equals four. Now the problem reads five plus four divided by two. The division needs to be done next, so now the problem is five plus two. That equals seven.

35. Given the equation three minus open parentheses x over five close parentheses equals one, solve for x.

A. one

B. five

C. ten

D. twenty

Answer: C. Begin by subtracting three from each side. Now you have negative x over five equals negative two. Next, multiple each side by five. This gives you negative x equals negative ten. Now, multiply each side by negative one, and you have x equals ten.

Note: the target word will be repeated at the end of the sentence.

36. Her grumpy attitude was an aberration. Aberration.

A. decision

B. deviation

C. absolution

D. emotion

Answer: B. The word aberration means something that differs from the norm. The same is true of the word deviation, so it is the correct answer.

37. He absconded with the dog. Absconded.

A. walked

B. played

C. left

D. spoke

Answer: C. The word abscond means to remove something, so "take" is the best synonym.

38. She cajoled him into taking her to the park. Cajoled.

A. threatened

B. convinced

C. paid

D. refused

Answer: B. To cajole means to persuade or to convince someone, so option B is the best answer.

39. He stared at the conflagration. Conflagration.

A. fire

B. hurricane

C. disruption

D. party

Answer: A. The word conflagration refers to a very intense fire, so option A is the best synonym.

40. She was amused by the disparate stories. Disparate.

A. funny

B. different

C. lengthy

D. entertaining

Answer: B. The word disparate refers to things that are different from each other, so option B is the best answer.

41. The mayor had a hard time dispelling the story about the council's proposal. Dispelling.

A. relating

B. observing

C. dismissing

D. supporting

Answer: C. To dispel something means to make it go away, so option C is the best answer.

42. Which word means most nearly the same thing as inane?

A. insane

B. inarticulate

C. dumb

D. pleased

Answer: C. The word inane refers to something that lacks intelligence.

43. Which word means most nearly the same as maxim?

A. maximum

B. saying

C. minimum

D. holdover

Answer: B. A maxim is a saying or a common phrase, so option B is the best answer.

44. Which word means most nearly the same thing as penchant?

A. liking

B. disliking

C. purchasing

D. allowing

Answer: A. To have a penchant for something means to have a liking for something, so option A is the best answer.

45. Which word means most nearly the same as pithy?

A. lengthy

B. fruity

C. short

D. dismal

Answer: C. The word pithy refers to something that is short.

46. Which word means most nearly the same as plethora?

A. absence

B. decrease

C. adequate

D. abundance

Answer: D. The word plethora refers to having an excess of something, so option D is the best answer.

47. Which word means most nearly the same thing as quaint?

A. mathematical

B. old-fashioned

C. elliptical

D. obtuse

Answer: B. The word quaint refers to something that is old-fashioned, so option B is the best answer.

48. Which word means most nearly the same thing as remiss?

A. failing

B. winning

C. reminding

D. nostalgia

Answer: Option A. To be remiss in something is to have neglected to have done it or to have failed to have done it, so option A is the best answer.

PARAGRAPH COMPREHENSION

Use the following paragraph to answer the next four questions.

From the vantage point of the twenty-first century, it can be difficult to believe that, for most of history, women did not have the right to vote. The struggle for women's suffrage was particularly fractious in England, where many women were imprisoned for protesting and made to endure forced feedings. But it is true that the arc of the universe bends, as so many have said, toward justice.

49. What is the author's purpose in mentioned the "arc of the universe"?

A. to explain how basic science supports democracy

B. to suggest that women's right to vote is part of a just society

C. to emphasize women's contributions to science

D. to show how math informs political decision-making

Answer: B. This question tests your ability to distinguish literal from figurative meanings. The reference to the arc is metaphorical, which means that options A, C, and D are incorrect, because they take the reference literally. This leaves option B as the correct choice.

50. The author would be LEAST likely to agree with which of these statements?

A. everyone should have the right to vote

B. authorities are not always just to people seeking their rights

C. societies can change

D. women's place is in the home

Answer: D. This question requires you to make an inference. The author is likely to agree with options A, B, and C, since they are each hinted at in the passage. But since the author supports the idea of women gaining rights, it is unlikely that the author would support the idea that a woman's place is in the home.

51. Why does the author mention the twenty-first century?

A. to tell when women were able to vote

B. to show how many people don't know about history

C. to emphasize how technology has changed

D. to suggest which century is most important

Answer: B. To answer this question carefully requires a close reading of the passage. The reason that the author mentions this date is to suggest that people today are sometimes not aware of how much things have changed in recent decades. None of the other answer options has any support in the passage.

52. Where would you be most likely to find this passage?

A. a science-fiction novel

B. a science textbook

C. a biography

D. an eighteenth-century novel

Answer: C. Since the passage references events after the eighteenth-century, option D is not possible. While it is remotely possible that this passage could appear in a science-fiction novel or a science textbook, it is unlikely because it would be difficult to imagine how it would be relevant. On the other hand, a biography—perhaps of a suffragette or a political figure—may well contain a passage like this one, so it is the most likely answer.

Use the following passage to answer the next four questions.

Michael gazed longingly at the display window, taking in the plump pastries, juicy tarts, and fresh donuts. The smell was enough to set his mouth watering. Suddenly, he noticed the gaze of the baker, and, taking in the venom in his eyes, he returned to the street and resumed asking passersby for spare change. They ignored him.

53. Why does the author mention venom?

A. to suggest to the reader that the baker is a space alien

B. to suggest to the reader that the baker is sick

C. to suggest to the reader that the baker is angry at Michael

D. to suggest to the reader that the baker is busy

Answer: C. This question tests your ability to identify figurative language. There is not literally venom in the baker; rather, the author is trying to show that the baker does not want Michael gazing at his baked goods.

54. Which word best describes Michael?

A. aloof

B. poor

C. neutral

D. angry

Answer: B. This question requires you to make an inference. The passage suggests that Michael is poor because, at the end, he is begging for money. There is no evidence in the passage for any of the other answer options.

55. Which would be the best title for this passage?

A. Data on Poverty in America

B. The Obesity Crisis

C. Michael's Tuesday

D. Baking Tricks

Answer: C. If you consider the passage as a whole, it is describing what happened to Michael. None of the other answers are supported by the entire passage.

56. How does the author characterize the baker?

A. unfeeling

B. friendly

C. distracted

D. gregarious

Answer: A. The baker is portrayed as someone who not only does not help the poor but also does not even want them to look at his baked goods. This suggests that the baker is unfeeling.

Use the following paragraph to answer the next five questions.

Prohibition—the banning of alcohol—is the only instance in United States history where the Constitution has been amended in an effort to limit the rights of American citizens. Beginning in nineteen twenty and lasting over a decade, it was illegal to produce, import, transport, or sell alcohol in the United States. The effort was well-intentioned, and it gained popularity as tales of workingmen drinking their paychecks and neglecting their families shocked the conscience of citizens. But there was an ugly undercurrent, as these workingmen were almost always portrayed as newcomer immigrants, different from the old stock.

57. The author implies that which of the following led to increased support for prohibition?

A. new scientific data

B. racism

C. sexism

D. budget problems

Answer: B. The final sentence implies that support for prohibition was rooted in racism—note the references to immigrants and "old stock." While it is possible that other issues were at play, none are mentioned in this passage, so there is no support in the passage for the other answers.

58. Why does the author use the phrase "drinking their paychecks"?

A. to condemn a trend of adding paper to alcohol

B. to condemn a popular new alcoholic drink

C. to suggest that alcohol use led to poverty

D. to suggest that alcohol use led to unemployment

Answer: C. This question is testing your ability to understand the figurative use of language. The reference to drinking paychecks is not meant to be taken literally, so options A and B do not make sense. And option D does not work since an unemployed person would not have a paycheck.

59. Which of the following is a possible date for the end of Prohibition?

A. nineteen twenty

B. nineteen twenty-two

C. nineteen twenty-seven

D. nineteen thirty-three

Answer: D. This question requires you to read closely and notice details. The passage stated that Prohibition began in nineteen twenty and lasted over a decade, which means that option D is the only possible answer.

60. Which would be the best title for this passage?

A. The Problems of the Workingman

B. Immigration in the Early Twentieth Century

C. Causes of Prohibition

D. The Results of Prohibition

Answer: C. The passage mentions most of these answer choices, but the only one that applies to the whole passage, and the only one that focuses on the main idea of the passage, is Causes of Prohibition.

61. Which of these statements would the author be most likely to agree with?

A. the Constitution has never been amended

B. Constitutional amendments usually restrict individual rights

C. Constitutional amendments rarely restrict individual rights

D. the Constitution is out of date

Answer: C. This question requires you to read closely. The author states near the beginning of the passage that Prohibition was the only constitutional amendment that limited individual rights, so option C is the best choice.

62. Electricity can best be described by which statement?

A. Electricity is the flow of electrons.

B. Electricity is the flow of heated water.

C. Electricity is the destruction of electrons.

D. Electricity is the creation of electrons.

Answer: A. Electricity involves the movement of electrons, so option A is the best answer.

63. What is the function of a resistor?

A. To change heat to electricity.

B. To generate electricity.

C. To slow the flow of electricity.

D. To magnify the power of electricity.

Answer: C. A resistor is any device that slows the flow of electricity.

64. What is the defining feature of a parallel circuit?

A. All the wires are exactly parallel to each other.

B. The electricity has to flow along one path.

C. The electricity can take one of several routes.

D. The circuit is broken in parallel.

Answer: C. In a series circuit, the electricity has to follow one path. By contrast, in a parallel circuit, the current may take one of several routes through the circuit.

65. How is power measured?

A. watts

B. ohms

C. volts

D. meters

Answer: A. Power is the rate at which electrical energy is transferred in a circuit; it is measured in watts.

66. An object that conducts current more efficiently than an insulator but less efficiently than a conductor is called what?

A. a short circuit

B. a parallel series

C. a semiconductor

D. a superconductor

Answer: C. The definition of a semiconductor is a substance that is between an insulator and a conductor in terms of its ability to conduct electricity.

67. Ohm's Law states that current multiplied times resistance is equal to what?

A. voltage

B. energy

C. distance

D. amplitude

Answer: A. Ohm's Law states that voltage equals current times resistance.

68. All metals fit into which category?

A. insulators

B. resistors

C. conductors

D. circuits

Answer: C. We say that an object is a good conductor if it allows electrons to flow easily. All metals are conductors.

69. Why are electrical wires usually surrounded by plastic?

A. to complete the circuit

B. to increase the conductivity

C. because plastic is an insulator

D. to create a direct current

Answer: C. Plastic is a good insulator, and metal is a good conductor. Electricity always follows the path of least resistance in situations where there is more than one path available, which means that it will stay in the metal wire and not flow through the plastic.

70. How does electricity flow?

A. from low to high potential energy

B. from high to low potential energy

C. from parallel to series

D. from volts to watts

Answer: B. Electricity flows from an area of high potential energy to an area of low potential energy until both have the same potential energy. This flow is called a current.

71. If you were to add a lightbulb to a circuit, which term would describe the bulb?

A. a generator

B. a parallel

C. a load

D. a volt

Answer: C. Anything we place in the circuit that does some work, such as a lightbulb, is called a load.

72. What is the purpose of a capacitor?

A. to increase energy

B. to store a charge

C. to do work

D. to insulate

Answer: B. A capacitor is a device that can store a charge.

73. A picture shows a lightbulb attached to a battery by a wire. Is this a picture of a circuit?

A. yes, because there is a power source and a load

B. yes, because there is a wire and a power source

C. no, because there is not a switch

D. no, because a circuit needs to form a closed loop

Answer: D. A circuit, by definition, has to be a closed loop. So this would not be a circuit because there is no loop. A switch is not necessary.

74. Which tool should be used when extremely precise measurements are needed?

A. a level

B. plumb bob

C. micrometer

D. tape measure

Answer: C. All of these answer choices can be used for measurements, but only a micrometer is capable of very precise measurements.

75. What is the main difference between a flathead and a Phillips head screwdrivers?

A. their length

B. the shape of the head

C. the style of handle

D. their material

Answer: B. A flathead screwdriver has an end that looks like a minus sign, but a Phillips head screwdriver has a head that looks like a plus sign.

76. A builder wants to determine if a doorframe is straight up and down. Which tool is best for this job?

A. a plumb bob

B. pliers

C. a carpenter's square

D. calipers

Answer: A. A plum bob is a weight hanging from a string that can be used to determine if something is running precisely up and down, since the string will hang straight down.

77. What is the main function of the suspension system in a car?

A. to reduce fuel use

B. to start the engine

C. to make the ride smooth

D. to convert fuel to heat

Answer: C. The suspension system is designed to maintain enough friction with the road for safety and to keep the ride smooth.

78. What is the purpose of brake fluid?

A. to stop the engine from overheating

B. to remove toxic waste from the car

C. to power pistons to stop the wheels

D. to lubricate the wheels

Answer: C. Brake fluid moves through the brake lines. This fluid powers pistons, which are connected to the disc brake pad or brake shoe. This very quickly slows the wheel and ultimately stops its rotation.

79. If two metal parts of an engine are rubbing against each other and damaging each other, what fluid is missing?

A. diesel fuel

B. oil

C. brake fluid

D. windshield washer fluid

Answer: B. Oil lubricates parts that would otherwise come in direct contact.

80. What is mixed with the fuel when an engine works properly?

A. water

B. oil

C. brake fluid

D. air

Answer: D. Air is mixed with liquid fuel in the carburetor. This is necessary for combustion to happen properly.

81. What is the purpose of the fuel pump?

A. it moves the fuel from the fuel tank to the carburetor

B. it limits the pollution caused by fuel

C. it removes the pollution caused by fuel

D. it increases the energy in the fuel

Answer: A. The fuel pump moves the fuel from the fuel tank to the carburetor.

82. What is the function of the crankshaft?

A. to move fuel from the tank to the engine

B. to keep the ride smooth

C. to convert motion from up-and-down to rotary motion

D. to increase the battery life

Answer: C. Pistons create an up-and-down motion, but wheels require a rotary motion. The crankshaft converts the motion.

83. Which of the following best describes a hybrid engine?

A. it is a traditional internal combustion engine only

B. it is a combination of internal combustion and electric motor

C. it is an electric motor only

D. it is half car and half truck

Answer: B. A hybrid combines an internal combustion engine with electric motor.

84. What is the purpose of spark plugs?

A. to process pollutants before they are released

B. to increase fuel efficiency

C. to reduce noise

D. to generate a spark

Answer: D. The spark, from the spark plugs, is used to ignite the fuel vapor. This creates combustion, which is what powers the car.

85. What is the first step in a four-stroke engine?

A. intake

B. exhaust

C. combustion

D. compression

Answer: A. The first step is intake, which refers to the fuel and air mixture entering the cylinder.

86. Which of the following is not one of the six simple machines?

A. a pulley

B. a screw

C. a circuit

D. a lever

Answer: C. The six simple machines are the pulley, screw, lever, wheel and axle, inclined plane, and wedge.

87. What is one disadvantage of using simple machines?

A. they require less force to move an object

B. they require more force to move an object

C. they require the object be moved over a longer distance

D. they require the object be moved over a shorter distance

Answer: C. Note that option A is factually true, but it is an advantage—not a disadvantage. Generally, simple machines require less force be applied over a longer distance.

88. Which is the best definition of a pulley?

A. a surface that is higher on one end than on the other

B. a bar that rotates around a specific point

C. two connected planes

D. a rope and a wheel

Answer: D. The basic definition of a pulley is that it is a wheel with a groove in it that permits a rope to fit in the groove.

89. Newton's First Law of Motion states which of the following about an object that is at rest?

A. it is immune from friction

B. it tends to stay at rest

C. it anticipates motion

D. it creates a reaction

Answer: B. Newton's first law states that whether something is at rest or in motion, it will stay that way until another force acts on it.

90. If you give a ball a push, it will eventually stop moving. Which of the following is responsible for that?

A. friction

B. dynamism

C. Pascal's Law

D. mechanical advantage

Answer: A. Friction is the force that resists motion, so friction is what will cause the ball to stop moving.

91. Which term best describes the force applied when a screwdriver is used?

A. friction

B. torque

C. velocity

D. acceleration

Answer: B. Torque is the force that causes an object to rotate, so it describes the force applied when a screwdriver is used.

92. Which of the following is included in the definition of a "fluid" in scientific terms?

A. liquids

B. gases

C. gases and liquids

D. solids and liquids

Answer: C. The word "fluid" refers to liquids and gases.

93. Which of the following would you observe when you press on a water balloon?

A. the balloon only bulges near where you touched it

B. the balloon bulges equally throughout

C. the balloon does not change its shape

D. the pressure decreases overall

Answer: B. Pascal's Law states that if you change the pressure at any location in a fluid that is in an enclosed space, the change in pressure transmits equally through the fluid.

94. An object that is very good at returning to its original shape after it has been stretched can best be described in what way?

A. elastic

B. not elastic

C. buoyant

D. not buoyant

Answer: A. Elasticity refers to the ability of an object to return to its original shape after being compressed or stretched.

95. A water droplet that forms a shape similar to a sphere is displaying which property?

A. elasticity

B. torque

C. surface tension

D. friction

Answer: C. When molecules are strongly attracted to each other on the surface of a liquid, we say that that liquid has a high surface tension. This is why the surface of a small amount of water can take on a rounded shape.

96. Which of the following is responsible for the fact that efficiency is always less than one hundred percent?

A. electrical waste

B. friction

C. increased distance

D. torque

Answer: B. Efficiency is always less than one hundred percent because there is always some friction that needs to be overcome when work is done.

97. Which equation properly describes work?

A. work equals torque times distance

B. work equals force times distance

C. work equals power divided by time

D. work equals force divided by distance

Answer: B. The correct equation is that work equals force times distance.

98. Which is the correct term for the amount of motion than an object has?

A. work

B. torque

C. momentum

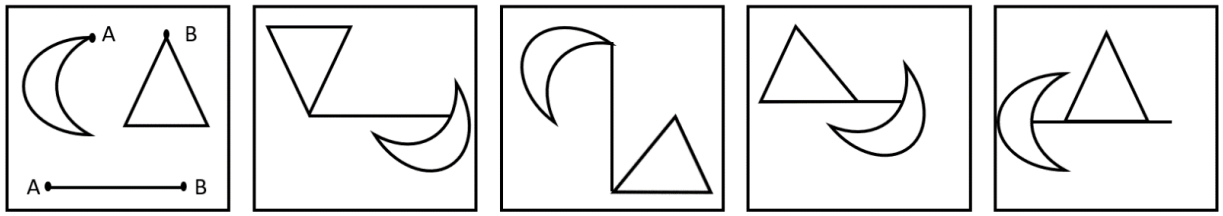
D. gravity

Answer: C. Momentum refers to the amount of motion that an object has. The formula for determining momentum is mass times velocity.

Assembling Objects

Use Figure Twenty-Six to answer the next question.

Figure Twenty-Six



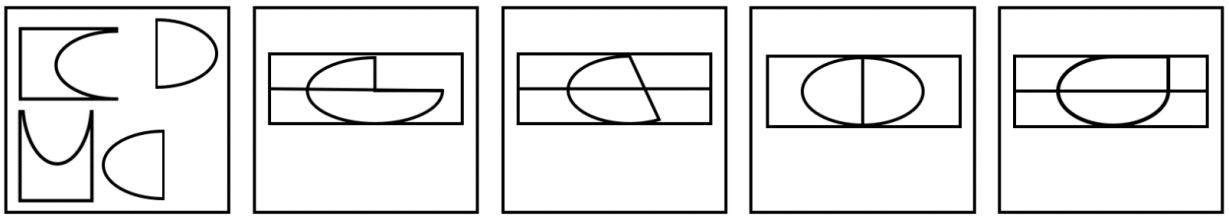
PROBLEM A B C D

99. Which answer option shows the shapes in the problem arranged so that both points labelled A are connected and both points labelled B are connected?

Answer: B. Begin by noticing that, on the crescent shape, point A is located at the tip of the crescent. Notice that in options A, C, and D, the line intersects with the crescent in the middle, not at the tip. This means that option B is the only possible answer.

Use Figure Twenty-Seven to answer the next question.

Figure Twenty-Seven



PROBLEM A B C D

100. The shapes in the problem can be rearranged to form the figure in which answer choice?

Answer: C. Notice that the problem has two half circles and two shapes that appear to be a rectangle with a half-circle carved out. The only answer option that matches this pattern is option C.