DOWNLOAD PDF WHEN WORK IS DONE

Chapter 1 : When I Work | Free Online Employee Scheduling Software and Time Clock

In physics, a force is said to do work if, when acting, there is a displacement of the point of application in the direction of the force. For example, when a ball is held above the ground and then dropped, the work done on the ball as it falls is equal to the weight of the ball (a force) multiplied by the distance to the ground (a displacement).

I agree that determining what is positive and what is negative can be confusing. One reason is because in a closed, conservative system, whenever something is losing energy, there is guaranteed to be something else that is gaining energy. And in a conservative open system where somebody or something is doing work, but the details are not known or given it can get confusing. Put yourself in the position of whatever it is that is actually doing the work, whether its specified in the problem or not. You are the one putting the effort into whatever it is that is being done. If you are pushing something, then you are putting energy into it ignoring friction here - we are speaking of conservative forces. If you are pushing a block forward, accelerating it forward in the same direction as its velocity , it is increasing in kinetic energy. You are doing positive work on it. Assume you are accelerating a block forward on the positive x axis, and its velocity is also positive x. The end result is positive. You have done positive work on the block, and it has gained energy as a result. The sytem has gained energy i. But as it works out, most people are only interested in the system, so your net energy change is not discussed. Suppose we have the same situation, but the velocity in the block is in the opposite direction. And by the same respect, you are actually gaining energy on this one assuming you are the one doing the pushing along the positive x axis. So in this example, the work that you do on the block is negative. So put yourself in there! Now you are the one who is going to push that charge in from infinity. Imagine yourself pushing this positive charge toward another positive charge. You are the one putting work and effort into this. So you are giving energy to the charge which you are moving or rather the system in general. Yes, there is a force emanating from the fixed charge that is in the opposite direction of movement. But there is another force, at least as large, coming from you! Your force wins because you are able to push the charge forward. So both F and s are in the same direction. You have done positive work on the charge, and it has gained positive energy. Switching to the case where the charges are oppositely charged, there is an attractive force between the charges. In this case, the charge is pulling you along with it. Think of a big dog on a leash that pulls you along with it. The work that you try to do pull back is futile. The sytem is doing work on you. In this case, your pulling force is in the opposite direction the charge ends up moving i. Thus the work that you do on the charge is negative. In other words, the system has done work on you, thus the system has lost potential energy. In 2 , the answer is 4. However, I do not understand why it is a positive answer. Again, put yourself in there. If you are the one pushing the electron, and you give energy to the system, you have done positive work. All of the above ignores ignores friction and such. It applies to conservative systems only.

Chapter 2 : Work, Transfer of Energy | Zona Land Education

Work done by a force. Work is done whenever a force moves something over a distance. You can calculate the energy transferred, or work done, by multiplying the force by the distance moved in the direction of the force.

All Work and no Play Work, work, work. You might head off to your job one day, sit at a computer, and type away at the keys. To a physicist, only parts of it are. Work is done when a force that is applied to an object moves that object. A force of 10 newtons, that moves an object 3 meters, does 30 n-m of work. A newton-meter is the same thing as a joule, so the units for work are the same as those for energy â€" joules. Sitting and looking at a computer screen is not work. Tapping on the keyboard and making the keys move is work. Your fingers are applying a force and moving the keys. Driving to your job is not work because you just sit, but the energy your car engine uses to move the car does work. You have to exert a force AND move something to qualify as doing work. Imagine that you are holding a brick above the ground. Slowly, your arm gets tired, the brick feels heavier and heavier, and you finally have to stop to let your arm rest. Even though you put forth a lot of effort to hold the brick up, did you do any work on the brick? No work was done if no movement happened. If you lifted the brick again after your arm had rested, that would be work. Transfer of Energy Work transfers energy from one object to another. Work is also linked to the expansion and compression of gases. When a gas tries to expand , it exerts an increasing force on the surfaces of a container and may make those surfaces move. The gas would then be doing work and transferring energy to the container. If you heat a balloon carefully , the molecules of air in the balloon gain energy and strike the inner walls of the balloon with greater force. Because the inner surface of the balloon is flexible, that surface moves outward. The air does work, and transfers energy to the balloon. If you compress a balloon, you do work, and transfer energy to the air inside the balloon. Measuring Work for Gases When scientists measure the work done on, or by, gases, they look at the system at the beginning and the end of the project. They look at the initial and final states. W stands for work, P is the pressure of the system for gases , and delta V is the change in volume for the system. The delta values are taken at the beginning and end. Sometimes they might take measurements while things are happening. Those are measurements of intermediate states. They could then use the intermediate measurements to calculate work, and then total those work values up to figure the total work done. Or search the sites for a specific topic.

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Chapter 3 : Positive vs. Negative Work | Physics Forums

The total work done is J (the sum of the two parts). 5. A force of 50 N acts on the block at the angle shown in the diagram. The block moves a horizontal.

Work is the transfer of energy. In physics we say that work is done on an object when you transfer energy to that object. If you put energy into an object, then you do work on that object mass. If a first object is the agent that gives energy to a second object, then the first object does work on the second object. The energy goes from the first object into the second object. At first we will say that if an object is standing still, and you get it moving, then you have put energy into that object. The object has kinetic energy as a result of your work. You pushed it through a displacement, you did work on the object. For example, a golfer uses a club and gets a stationary golf ball moving when he or she hits the ball. The club does work on the golf ball as it strikes the ball. Energy leaves the club and enters the ball. This is a transfer of energy. Thus, we say that the club did work on the ball. And, before the ball was struck, the golfer did work on the club. The club was initially standing still, and the golfer got it moving when he or she swung the club. So, the golfer does work on the club, transferring energy into the club, making it move. The club does work on the ball, transferring energy into the ball, getting it moving. Formula For Work In almost all cases considered when studying mechanical forms of energy, when work is done on an object a force is applied to the object, and the object is displaced while this force is acting upon it. That is, the object moves as a result of a force being placed on it. In the previous golf example the club places a force on the ball, and this force acts on the ball over the short distance through which the club and the ball are in contact as the ball is being hit. Energy is transferred as the force acts over this displacement. The amount of work is calculated by multiplying the force times the displacement. That formula looks like this: A word about dot products: On the right of the equal sign is the dot product of the force vector times the displacement vector. If the object is displaced in the same direction as the force is pushing, then this dot product becomes a simple multiplication of the size of the force times the size of the displacement. At first we will consider only forces that are aimed in the same direction as the displacement. So, we will be using the simple multiplication mentioned above. For example, we will imagine an object being pushed horizontally to the right, and the object will be moving horizontally to the right as a result of this applied force. Below is an animation that shows just that. The force vector is drawn in blue. It is pushing the object to the right. This force is applied over a displacement. The displacement vector is shown in red. The yellow object mass starts out standing still. While the force is acting on the object the object picks up speed, that is, it accelerates. When the force quits acting, the object quits picking up speed; that is, it quits accelerating. A medium force acts on the object mass over a medium displacement: This picking up of speed means that the object is gaining more and more energy kinetic energy as the force is acting on it. While the force is acting upon the object, energy is being transferred to the object. Therefore work is being done on the object. Whatever we might imagine is providing the force is the agent that is doing work on the object. In our above discussion the force could be applied by the golf club, and the object in the animation represents the golf ball. This, of course, would need to be thought of as in slow motion! Now, since work is calculated as the product of force times displacement, many different combinations of forces and displacements could yield the same work, or the same energy transfer. Using units of Joules J for work, Newtons N for force, and meters m for displacement: For example, compared to the above animation, the following animation has a larger force that acts over a shorter displacement, yet the same amount of work is ultimately done. A large force acts on the object mass over a small displacement: Again, the same amount of work is done. The same amount of energy is transferred. A small force acts on the object mass over a large displacement: For a while, though, we will consider only forces in the same direction as the displacement. Sample Calculation How much work is done if a force of 20 N is used to displace an object 3 m?

Chapter 4 : Work and energy

Work is zero if Cos Î¸ is zero or Î¸ = Ï€/2. this explains why no work is done by the porter in carrying the load. As the porter carries the load by lifting it upwards and the moving forward it is obvious the angle between the force applied by the porter and the displacement is 90 o.

Specifically, according to Carnot: We use here motive power to express the useful effect that a motor is capable of producing. This effect can always be likened to the elevation of a weight to a certain height. It has, as we know, as a measure, the product of the weight multiplied by the height to which it is raised. In this experiment, the friction and agitation of the paddle-wheel on the body of water caused heat to be generated which, in turn, increased the temperature of water. Using these values, Joule was able to determine the mechanical equivalent of heat. The modern day definitions of heat, work, temperature, and energy all have connection to this experiment. Overview[edit] Thermodynamic work is performed by actions such as compression, and including shaft work, stirring, and rubbing. A simple case is work due to change of volume against a resisting pressure. Work without change of volume is known as isochoric work, for example when an outside agency, in the surroundings of the system, drives a frictional action on the surface of the system. In this case the dissipation is usually not confined to the system, and the quantity of energy so transferred as work must be estimated through the overall change of state of the system as measured by both its mechanically and externally measurable deformation variables such as its volume , and its corresponding non-deformation variable such as its pressure. In a process of transfer of energy as work, the change of internal energy of the system is then defined in theory by the amount of adiabatic work that would have been necessary to reach the final from the initial state, such adiabatic work being measurable only through the externally measurable mechanical or deformation variables of the system, that provide full information about the forces exerted by the surroundings on the system during the process. In an important sign convention, work that adds to the internal energy of the system is counted as positive. Nevertheless, on the other hand, for historical reasons, an oft-encountered sign convention is to consider work done by the system on its surroundings as positive. Although all real physical processes entail some dissipation of kinetic energy, it is a matter of definition in thermodynamics that the dissipation that results from transfer of energy as work occurs only inside the system. Energy dissipated outside the system, in the process of transfer of energy, is not counted as thermodynamic work, because it is not fully accounted for by macroscopic forces exerted on the system by external factors. Thermodynamic work does not account for any energy transferred between systems as heat or through transfer of matter. Some authors have considered this equivalence to the lifting of a weight as a defining characteristic of work. For a closed thermodynamic system, the first law of thermodynamics relates changes in the internal energy to two forms of energy transfer, as heat and as work. In theory, heat is properly defined for a process in a closed system no transfer of matter by the amount of adiabatic work that would be needed to effect the change occasioned by the process. In practice it is often estimated calorimetrically, through change of temperature of a known quantity of calorimetric material substance; it is of the essence of heat transfer that it is not mediated by the externally defined forces variables that define work. This distinction between work and heat is essential to thermodynamics. Beyond the conceptual scope of thermodynamics proper, heat is transferred by the microscopic thermal motions of particles and their associated inter-molecular potential energies, [14] or by radiation. There are several forms of dissipative transduction of energy that can occur internally within a system at a microscopic level, such as friction including bulk and shear viscosity , [18] chemical reaction , [1] unconstrained expansion as in Joule expansion and in diffusion , and phase change ; [1] these are not transfers of heat between systems. Convection of internal energy is a form a transport of energy but is in general not, as sometimes mistakenly supposed a relic of the caloric theory of heat , a form of transfer of energy as heat, because convection is not in itself a microscopic motion of microscopic particles or their intermolecular potential energies, or photons; nor is it a transfer of energy as work. Nevertheless, if the wall between the system and its surroundings is thick and contains fluid, in the presence of a gravitational field, convective circulation within the wall can be considered as indirectly mediating transfer of energy as heat between the system and its surroundings, though they are not in direct contact. For an open system, the first law of thermodynamics admits three forms of energy transfer, as work, as heat, and as energy associated with matter that is transferred. The latter cannot be split uniquely into heat and work components. Formal definition[edit] In thermodynamics, the quantity of work done by a closed system on its surroundings is defined by factors strictly confined to the interface of the surroundings with the system and to the surroundings of the system, for example, an extended gravitational field in which the system sits, that is to say, to things external to the system. There are a few especially important kinds of thermodynamic work. A simple example of one of those important kinds is pressureâ€"volume work. The pressure of concern is that exerted by the surroundings on the surface of the system, and the volume of interest is the negative of the increment of volume gained by the system from the surroundings. It is usually arranged that the pressure exerted by the surroundings on the surface of the system is well defined and equal to the pressure exerted by the system on the surroundings. This arrangement for transfer of energy as work can be varied in a particular way that depends on the strictly mechanical nature of pressureâ€"volume work. The variation consists in letting the coupling between the system and surroundings be through a rigid rod that links pistons of different areas for the system and surroundings. Then for a given amount of work transferred, the exchange of volumes involves different pressures, inversely with the piston areas, for mechanical equilibrium. This cannot be done for the transfer of energy as heat because of its non-mechanical nature. Isochoric work for a body in its own state of internal thermodynamic equilibrium is done only by the surroundings on the body, not by the body on the surroundings, so that the sign of isochoric work with the present sign convention is always negative. When work is done by a closed system that cannot pass heat in or out because it is adiabatically isolated, the work is referred to as being adiabatic in character. Adiabatic work can be of the pressureâ€"volume kind or of the isochoric kind, or both. Sign convention[edit] Classically, a negative value of work indicates that a positive amount of work done by the system leads to energy being lost from the system. This sign convention has historically been used in many physics textbooks and will be used in the present article.

Chapter 5 : Pressure-volume work (formula for work) (article) | Khan Academy

"By convention, now generally equation (1) is used" Equation (2) was the equation used when considering the work done by steam engines and is still used by engineers and physicists. Equation (1) is the equation which was formally defined by the IUPAC a few decades ago.

What is Work, Energy and Power? Definitions Work can be defined as transfer of energy. In physics we say that work is done on an object when you transfer energy to that object. If one object transfers gives energy to a second object, then the first object does work on the second object. Work is the application of a force over a distance. Lifting a weight from the ground and putting it on a shelf is a good example of work. Work-Energy Principle --The change in the kinetic energy of an object is equal to the net work done on the object. Energy can be defined as the capacity for doing work. The simplest case of mechanical work is when an object is standing still and we force it to move. The energy of a moving object is called kinetic energy. Types of Energy There are two types of energy in many forms: When two nuclei are joined together under millions of degrees of heat it is called fusion Electrical Energy --The generation or use of electric power over a period of time expressed in kilowatt-hours kWh , megawatt-hours NM or gigawatt-hours GWh. Chemical Energy --Chemical energy is a form of potential energy related to the breaking and forming of chemical bonds. It is stored in food, fuels and batteries, and is released as other forms of energy during chemical reactions. Mechanical Energy --Energy of the moving parts of a machine. Also refers to movements in humans Heat Energy -- a form of energy that is transferred by a difference in temperature What is Power Power is the work done in a unit of time. In other words, power is a measure of how quickly work can be done. One common unit of energy is the kilowatt-hour kWh. If we are using one kW of power, a kWh of energy will last one hour. How much work is done? Please enter your answer in the space provided: How much power is used? An example of Kinetic Energy would be: An example of Potential Energy would be: Which is not an example of Solar Radiation a microwaves.

Chapter 6 : Work (physics) - Wikipedia

System Work When work is done by a thermodynamic system, it is ususlly a gas that is doing the work. The work done by a gas at constant pressure is: For non-constant pressure, the work can be visualized as the area under the pressure-volume curve which represents the process taking place.

Discussion what is work? The target audience of this book is people with some amount of education. I consider adolescents or teenagers, if you prefer to be proto-adults. Somewhere along the line, you should have been introduced to the concept of energy. Those of you with a bit of formal education were probably given a lesson on energy at some point in your life. If so, then the chances are pretty good that you were given a definition of energy as "the ability to do work". If you were a good student or you just wanted to please your teacher, you probably heard this and said to yourself, "OK, energy is the ability to do work. Hopefully you were given the right answer, but chances are fifty-fifty you were shrugged off. Not because the right answer is so difficult to know, but rather because the right answer is so difficult to explain, or at least difficult to explain in a way that can be grasped quickly. I think this is mostly due to the fact that the word work has two meanings: So many words and so little said, no? Actually, quite the contrary. It says as much as it can in as few words as possible. Let me explain what work is though a series of mental images. Whenever an example is presented, remember that work is done whenever a force causes a displacement. Imagine that a physics teacher is standing motionless before a class of students. But doing this for any length of time will certainly drain him of energy just as if he pushed papers across his desk all day an example where a force does result in a displacement. Surely, you could now convince him that his definition of work must be wrong. Maybe a lesser teacher would cave under the pressure, but not a physics teacher. Inside the body the heart is pumping blood, the digestive system is grinding away on breakfast, receptors are driving molecules across cell membranes. We do work even as we sleep. Forces causing displacements are happening everywhere under our skins. The human body is a busy place. A physics teacher pushing papers across his desk is doing external work. A physics teacher standing motionless is not doing any significant external work. A physics teacher thinking deeply or lying in a coma is doing internal work. Extra credit if you can tell the difference between the two. A physics teacher doing anything â€” or nothing for that matter â€” is doing internal work. A physics teacher who is dead is not doing any work, internal or external. In mechanics, when we say work has been done we are often referring to external work. Hmm, well anytime arms and legs get moving the situation is moderately complex. We need to simplify things a little bit more. Give the teacher a book like a physics textbook and ask him to move the book around in a few simple ways. The question now is, "Did the teacher do any work on the book? For a teacher holding a book, or any other system for that matter, work is done whenever a force results in a displacement. Consider the following six examples presented three at a time. No work is done on a textbook when it is held at rest. Positive work is done on a textbook when it is raised vertically at a constant velocity. Positive work is also done on a textbook when it is raised diagonally at a constant velocity. The first example makes obvious sense. Holding a book without moving it surely results in no work being done on the book. Replace the teacher with a table or the floor. A book lies on the floor. What work is the floor doing? Nothing is going anywhere. Nothing is being done â€” not even work. The second and third examples also make sense. The teacher pushes on the book and it moves. A force resulted in a displacement. This agrees with our everyday notion of work. All is right with the world. No work is done on a textbook when it is carried horizontally at a constant velocity. Negative work is done on a textbook when it is lowered diagonally at a constant velocity. Negative work is also done on a textbook when it is lowered vertically at a constant velocity. The first one in this set is bothersome. It basically says that no work is done carrying a book across level ground. You have to read this last bit as an internal dialog for it to make sense. Work is done on an object whenever a force causes a displacement. In this example, the force applied is vertical but the displacement is horizontal. How does a vertical force affect horizontal motion? Horizontal forces affect horizontal motion. When motion and force are parallel, life is simple. When motion and force are not parallel, life is not simple. The angels leave and the demons take over. And by demons I mean vectors â€”

in particular, vector components. Work is done whenever a force or a component of a force results in a displacement. No component of the force is acting in the direction of motion when the book is moved horizontally with a constant velocity. The force and the displacement are independent. No work is done by the hand on the book. Take a look at the last two examples in this set of six. Here we see negative work being done. Given what I said about components, this may or may not make sense to you. Once again, when force and displacement are parallel, life is simple. The farther the two vectors get from parallel, the less work is done. Force and displacement are starting to point in opposite directions. This is negative work. The sign of work indicates the direction of a change. A negative sign indicates a loss of something. In the case of lowering a book, it means lowering its ability to do work â€” lowering its energy. Follow this line of reasoning. Raising a book takes work. Raising a book raises its energy. I can pound stuff with it â€" walnuts, insects, square pegs into round holes. The way I do this work is by lowering the book. This also lowers its energy. Raising the book does work on it. Lowering it undoes work on it. From a work or energy standpoint, the book has returned to its initial state. Numerically the positive work done raising it was cancelled by the negative work done lowering it resulting in zero work being done overall on the book. The situation is different for the smashed walnut, insect, or square peg. All other things being equal, applying a greater force should result in more work being done. Likewise, exerting a given force over a greater distance should result in more work being done. And as we discussed in the dozen or so paragraphs preceding this one, the component of the force parallel to the displacement is what matters. Work is directly proportional to the first two factors: Direction is handled with the cosine function. Cosine is greatest when the angle is zero the angle between two vectors pointing in the same direction is zero , zero at ninety degrees forces perpendicular to displacement do no work , and negative for obtuse angles forces acting opposite displacement undo work. Work is best defined by an equation.

Chapter 7 : Work and Energy Review - with Answers #1

The Work/Energy Equation says that the work done on an object (by the net force on it) equals its change in kinetic energy. So, to figure out how much work is done on an object, just calculate the change in its kinetic energy.

Work A Couple of Shockers: Undoubtedly, you have been taught that "Work equals force times distance. Work is sometimes force times distance, but not always. Work is more subtle than that, and in order to understand energy, you have to understand work to a greater depth. If you think that "work equals force times distance," then you probably think that you automatically do work every time you exert a force. In the diagram above, the green block is moving to the right. The red force F1 does work on the block because it has a component in the direction of motion. The blue force F2 does NOT do work on the block, because it does not have a component in the direction of motion. This will only happen if there is a component of the force in the direction that the object moves. Therefore, a force will do work only if the force has a component in the direction that the object moves. Calculating work can get, well, interesting. Fortunately for the Physics 1 student, you only need to be able to calculate work done by a force in the four simple cases shown below. For the more mathematically mature, there is a formula that you can use to calculate the work done by a constant force. Some of the following pages discuss calculating work done by a variable force , but that is for AP Physics students. Calculating the Work Done by a Constant Force: In Physics 1, you need to be able to calculate the work done by a force in four situations: Work done by the force F is: The direction of the force is in the same direction the object moves. The force the brakes exert to stop a car -Force x distance The direction of the force is perpendicular to the direction the object moves. The gravitational force the Earth exerts on the Moon 0 The force you exert when pushing on a wall 0 Why? The Key to Understanding: So, to figure out how much work is done on an object, just calculate the change in its kinetic energy If the kinetic energy increases, the change in kinetic energy will be positive. A numerical example is available. In this situation, the force tends to slow the object down, thereby decreasing its kinetic energy. If the kinetic energy decreases, then the change in kinetic energy is negative. Since the work done equals the change in kinetic energy, the work done by this force must be negative. There are a couple of ways to handle this: Keep in mind that direction matters with force and distance. If the direction of the force is opposite to the direction that the object moves, one or the other of them is acting in the negative direction. If the Force is Perpendicular to the Direction That the Object Moves In this case, the force does not change the speed of the object - just its direction. If the change in kinetic energy is 0, the work done on the object is 0, too. No distance - no work. Work is NOT Force! Many beginning physicists confuse "exerting a force" with "doing work.

Chapter 8 : Calculating the Amount of Work Done by Forces

states that when work is done on an object, a change in kinetic energy occurs Work = change in Kinetic Energy Because friction acts in the opposite direction of the motion of an object, kinetic energy must be decreased in order to maintain the above equation.

Forced Choice Questions 1. Which of the following statements are true about work? Include all that apply. Work is a form of energy. A Watt is the standard metric unit of work. Units of work would be equivalent to a Newton times a meter. Work is a time-based quantity; it is dependent upon how fast a force displaces an object. Superman applies a force on a truck to prevent it from moving down a hill. This is an example of work being done. An upward force is applied to a bucket as it is carried 20 m across the yard. A force is applied by a chain to a roller coaster car to carry it up the hill of the first drop of the Shockwave ride. The force of friction acts upon a softball player as she makes a headfirst dive into third base. An eraser is tied to a string; a person holds the string and applies a tension force as the eraser is moved in a circle at constant speed. A force acts upon an object to push the object along a surface at constant speed. By itself, this force must NOT be doing any work upon the object. A force acts upon an object at a degree angle to the direction that it is moving. This force is doing negative work upon the object. An individual force does NOT do positive work upon an object if the object is moving at constant speed. An object is moving to the right. A force acts leftward upon it. This force is doing negative work. A non-conservative force is doing work on an object; it is the only force doing work. Therefore, the object will either gain or lose mechanical energy. TRUE - Work is a form of energy, and in fact it has units of energy. FALSE - Work is not dependent on how rapidly the force displaces an object; power is time-based and calculated by force multiplied by speed. FALSE - Since Superman does not cause a displacement, no work is done; he is merely holding the car to prevent its descent down the hill. TRUE - There is a component of force in the direction of displacement and so this is an example of work. TRUE - There is a force and a displacement; the force acts in the opposite direction as the displacement and so this force does negative work. FALSE - For uniform circular motion, the force acts perpendicular to the direction of the motion and so the force never does any work upon the object. FALSE - If a force acts at a degree angle to the direction of motion, then the force does not do any work at all. Negative work is done when there is a component of force opposite the direction of motion. FALSE - There are many instances in which an individual force does positive work and yet the object maintains a constant speed. Consider a force applied to lift an object at constant speed. The force does positive work. Consider a car moving at constant speed along a level surface. The force of the road on the tires does positive work while air resistance does and equal amount of negative work. TRUE - A force which acts in a direction opposite the motion of an object will do negative work. TRUE - When non-conservative forces do work upon an object, the object will either gain or lose mechanical energy. Mechanical energy is conserved neither gained nor lost only when conservative forces do work upon objects.

Chapter 9 : Energy, Enthalpy, and the First Law of Thermodynamics

In this example, the gas has done work on the surroundings, which includes the piston and the rest of the universe. To calculate how much work a gas has done (or has.

Chemical Thermodynamics Thermodynamics is defined as the branch of science that deals with the relationship between heat and other forms of energy, such as work. It is frequently summarized as three laws that describe restrictions on how different forms of energy can be interconverted. Chemical thermodynamics is the portion of thermodynamics that pertains to chemical reactions. The Laws of Thermodynamics First law: Energy is conserved; it can be neither created nor destroyed. In an isolated system, natural processes are spontaneous when they lead to an increase in disorder, or entropy. The entropy of a perfect crystal is zero when the temperature of the crystal is equal to absolute zero 0 K. There have been many attempts to build a device that violates the laws of thermodynamics. Thermodynamics is one of the few areas of science in which there are no exceptions. The System and Surroundings One of the basic assumptions of thermodynamics is the idea that we can arbitrarily divide the universe into a system and its surroundings. The boundary between the system and its surroundings can be as real as the walls of a beaker that separates a solution from the rest of the universe as in the figure below. Or it can be as imaginary as the set of points that divide the air just above the surface of a metal from the rest of the atmosphere as in the figure below. Internal Energy One of the thermodynamic properties of a system is its internal energy, E, which is the sum of the kinetic and potential energies of the particles that form the system. The internal energy of a system can be understood by examining the simplest possible system: Because the particles in an ideal gas do not interact, this system has no potential energy. The internal energy of an ideal gas is therefore the sum of the kinetic energies of the particles in the gas. The kinetic molecular theory assumes that the temperature of a gas is directly proportional to the average kinetic energy of its particles, as shown in the figure below. The internal energy of an ideal gas is therefore directly proportional to the temperature of the gas. But the internal energy of the system is still proportional to its temperature. We can therefore monitor changes in the internal energy of a system by watching what happens to the temperature of the system. Whenever the temperature of the system increases we can conclude that the internal energy of the system has also increased. Assume, for the moment, that a thermometer immersed in a beaker of water on a hot plate reads This measurement can only describe the state of the system at that moment in time. Temperature is therefore a state function. It depends only on the state of the system at any moment in time, not the path used to get the system to that state. Because the internal energy of the system is proportional to its temperature, internal energy is also a state function. Any change in the internal energy of the system is equal to the difference between its initial and final values. First Law of Thermodynamics: It says that the change in the internal energy of a system is equal to the sum of the heat gained or lost by the system and the work done by or on the system. When the hot plate is turned on, the system gains heat from its surroundings. As a result, both the temperature and the internal energy of the system increase, and E is positive. When the hot plate is turned off, the water loses heat to its surroundings as it cools to room temperature, and E is negative. The relationship between internal energy and work can be understood by considering another concrete example: When work is done on this system by driving an electric current through the tungsten wire, the system becomes hotter and E is therefore positive. Eventually, the wire becomes hot enough to glow. Conversely, E is negative when the system does work on its surroundings. The sign conventions for heat, work, and internal energy are summarized in the figure below. The System and Work The system is usually defined as the chemical reaction and the boundary is the container in which the reaction is run. In the course of the reaction, heat is either given off or absorbed by the system. Furthermore, the system either does work on it surroundings or has work done on it by its surroundings. Either of these interactions can affect the internal energy of the system. Chemical reactions can do work on their surroundings by driving an electric current through an external wire. Reactions also do work on their surroundings when the volume of the system expands during the course of the reaction The amount of work of expansion done by the reaction is equal to the product of the pressure against which the system expands times the change in the volume of the system. Enthalpy Versus Internal Energy What would happen if we created a set of conditions under which no work is done by the system on its surroundings, or vice versa, during a chemical reaction? Under these conditions, the heat given off or absorbed by the reaction would be equal to the change in the internal energy of the system. At constant volume, the heat given off or absorbed by the reaction is equal to the change in the internal energy that occurs during the reaction. Most reactions, however, are run in open flasks and beakers. When this is done, the volume of the system is not constant because gas can either enter or leave the container during the reaction. The system is at constant pressure, however, because the total pressure inside the container is always equal to atmospheric pressure. If a gas is driven out of the flask during the reaction, the system does work on its surroundings. If the reaction pulls a gas into the flask, the surroundings do work on the system. We can still measure the amount of heat given off or absorbed during the reaction, but it is no longer equal to the change in the internal energy of the system, because some of the heat has been converted into work. We will therefore abbreviate the relationship between the enthalpy of the system and the internal energy of the system as follows. Because the reaction is run at constant pressure, the change in the enthalpy that occurs during the reaction is equal to the change in the internal energy of the system plus the product of the constant pressure times the change in the volume of the system.