

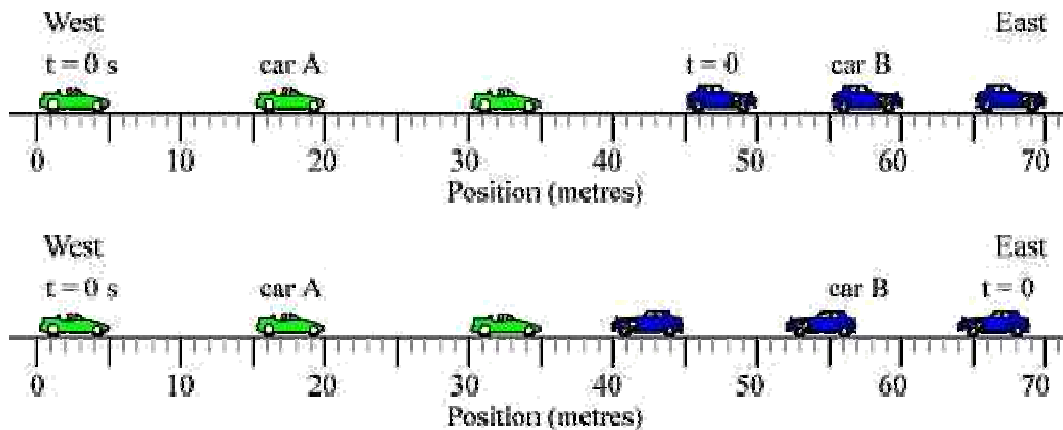
PHYSICS

1. YEAR



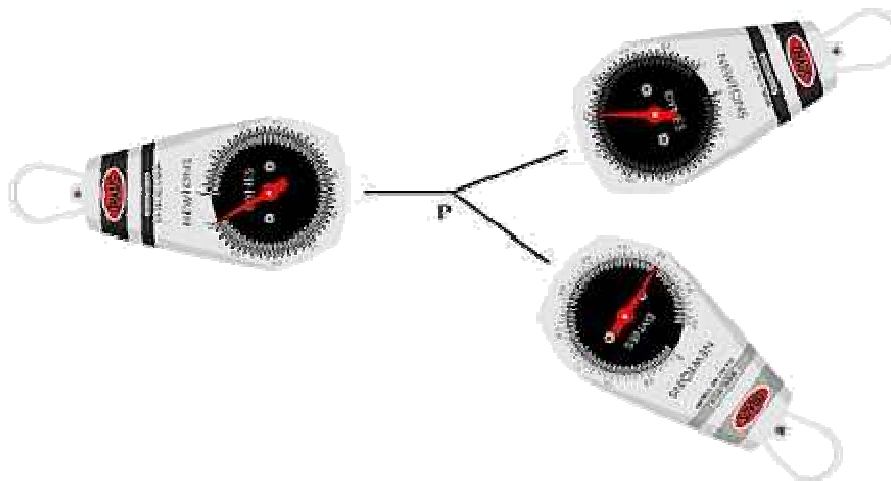
FRAMES OF REFERENCE

Two cars move parallel to each other and then at right angles to each other. How the motion of one car appears when looking from the other is investigated. The relative velocity equation is discovered and tested by applying it to someone running in the rain. It predicts what everyone does - hold the umbrella at a forward angle because that is the way the rain appears to be falling.



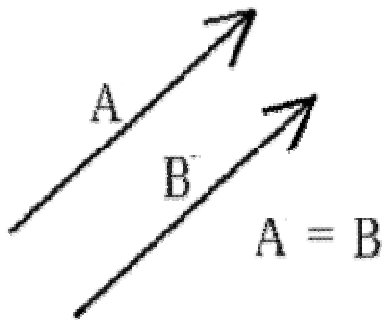
INTRODUCTION TO VECTORS

Using three pieces of string tied together at one end and a force measure attached to each of the other ends, students find that 3 plus 4 no longer equals 7. Using scale diagrams of the situation students learn that by using the tip to tail method of adding vectors, they obtain the 3 plus 4 equals 5 Newton outcomes they observed using the strings. Students learn to resolve vectors into components and the theory is checked using a dynamics cart on a slope. The parallel and perpendicular components of its weight are determined from a scale diagram and then measured.

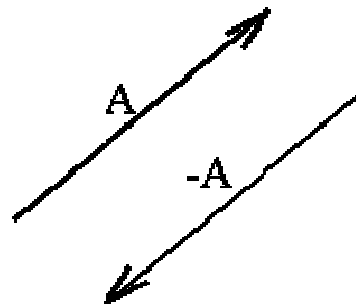


VECTORS

Panel 1



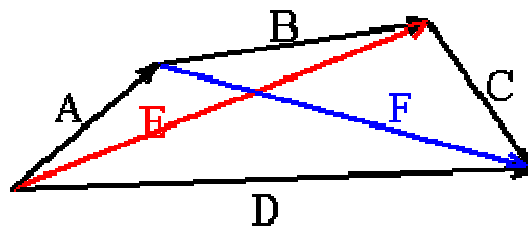
Panel 2



A vector having the same magnitude as A but in the opposite direction to A is denoted by $-A$, as shown in Panel 2.

The verification of the Associative law is shown in Panel 3. If we add A and B we get a vector E. And similarly if B is added to C, we get F. Now $D = E + C = A + F$. Replacing E with $(A + B)$ and F with $(B + C)$, we get $(A + B) + C = A + (B + C)$ and we see that the law is verified.

Panel 3



FORCE AND MOTION IN 2-D

Students apply forces to balls rolling on the desk. The speed of the ball and the strength and direction of the force is varied and the final speed and direction of the ball is noted. From the patterns of behaviour, students are asked to predict the direction and strength of the force that will produce a nominated outcome.



FORCE, MASS AND ACCELERATION

Using two sets of slotted masses, thick cotton, a mechanics/smart pulley, an interface and a PC, students discover the relationships between acceleration, force and mass. By controlling the size of the masses hanging from the string passing over the pulley, the students can vary the mass and keep the force constant and vary the force and keep the mass constant.



FREE FALL

The size of air resistance on falling objects is related to their size and speed. The effect of air resistance is related to the object's mass. The conditions are established where air resistance can be ignored. A stroboscopic picture of a falling golf ball is analysed and its speed versus time graph drawn. The acceleration of the ball is determined and related to the strength of gravity. Then the fun starts! Students are challenged to grab a bank note before it drops out from between their fingers. Grab it and it's your challenge. After everyone fails, the time for the note to drop out of reach is calculated. Then, reaction time of students is measured using a timer. This is found to be about twice the time of the calculation

NEWTON'S THREE LAWS OF MOTION

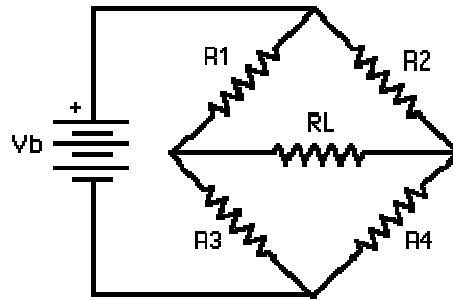
I. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

II. The relationship between an object's mass m , its acceleration a , and the applied force F is $F = ma$. Acceleration and force are vectors (as indicated by their symbols being displayed in slant bold font); in this law the direction of the force vector is the same as the direction of the acceleration vector.

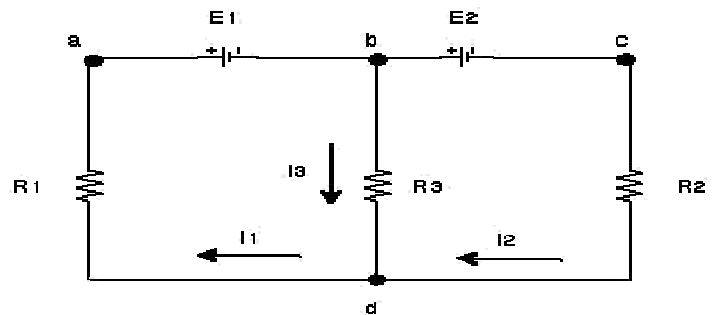
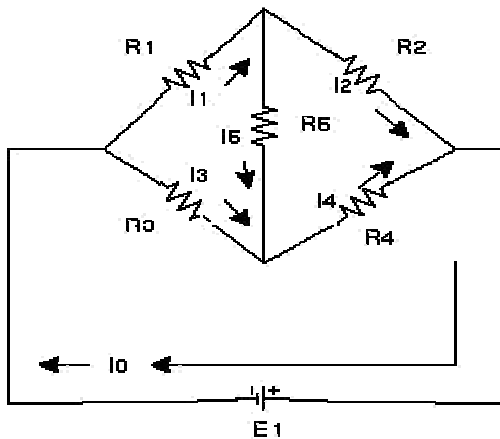
III. For every action there is an equal and opposite reaction.

WHEATSTONE BRIDGE

This model can be used to determine the null conditions of a Wheatstone bridge or to determine the out-of-null output voltage as a function of arm resistance. Resistors $R_1 \dots R_4$ are the four arms of the bridge and R_L represents the input resistance of the detector or null voltage read-out device. This model requires an iterative solution; the "guess" variable can be the voltage or current in any one of the arms. In the example variable sheet shown below, an off-null sensitivity of 24.8 mV per ohm is demonstrated for a nearly balanced 100 ohm bridge with an excitation voltage of 10 volts and $R_L=100K$

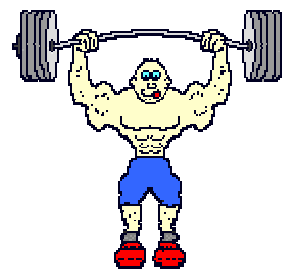


KIRCHOFFS LAWS (MAPLE) PICTURES



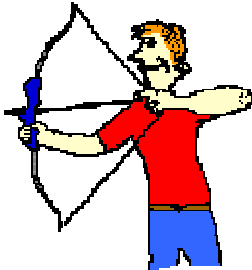
MECHANICAL ENERGY

It was said that work is done upon an object whenever a force acts upon it to cause it to be displaced. Work is force acting upon an object to cause a displacement. In all instances in which work is done, there is an object which supplies the force in order to do the work. If a World Civilization book is lifted to the top shelf of a student locker, then the student supplies the force to do the work on the book. If a plow is displaced across a field, then some form of farm equipment (usually a tractor or a horse) supplies the force to do the work on the plow. If a pitcher winds up and accelerates a baseball towards home plate, then the pitcher supplies the force to do the work on the baseball. If a roller coaster car is displaced from ground level to the top of the first drop of the Shock Wave, then a chain (driven by a motor) supplies the force to do the work on the car. If a barbell is displaced from ground level to a height above a weightlifter's head, then the weightlifter is supplying



A weightlifter applies a force to cause a barbell to be displaced. The barbell then possesses mechanical energy - all in the form of potential energy.

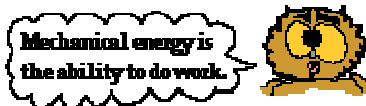
a force to do work on the barbell. In all instances, an object which possesses some form of energy supplies the force to do the work. In the instances described here, the objects doing the work (a student, a tractor, a pitcher, a motor/chain) possess *chemical potential energy* stored in food or fuel which is transformed into work. In the process of doing work, the objects do the work exchange energy in one form to do work on another object to give it energy. The energy acquired by the objects upon which work is done is known as mechanical energy.



A drawn bow possesses mechanical energy in the form of elastic potential energy.

Mechanical energy is the energy which is possessed by an object due to its motion or its stored energy of position. Mechanical energy can be either **KINETIC ENERGY** (energy of motion) or **POTENTIAL ENERGY** (stored energy of position). Objects have mechanical energy if they are in motion and/or if they are at some position relative to a *zero potential energy position* (for example, a brick held at a vertical position above the ground or zero height position). A moving car possesses mechanical energy due to its motion (**KINETIC ENERGY**). A moving baseball possesses mechanical energy due to both its high speed

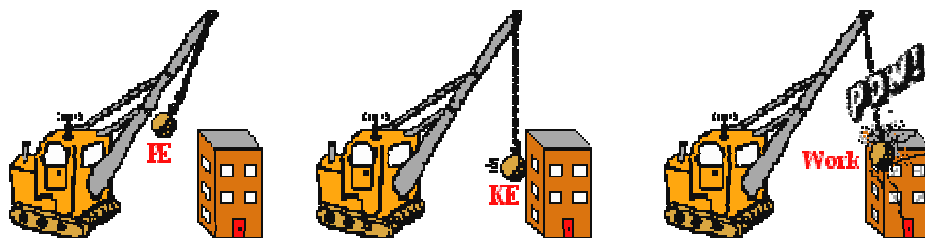
(**KINETIC ENERGY**) and its vertical position above the ground (gravitational **POTENTIAL ENERGY**). A World Civilization book at rest on the top shelf of a locker possesses mechanical energy due to its vertical position above the ground (gravitational **POTENTIAL ENERGY**). A barbell lifted high above a weightlifter's head possesses mechanical energy due to its vertical position above the ground (gravitational **POTENTIAL ENERGY**). A drawn bow possesses mechanical energy due to its stretched position (elastic **POTENTIAL ENERGY**).



An object which possesses mechanical energy is able to do work. In fact, mechanical energy is often defined as the ability to do work. Any object which possesses mechanical energy - whether it is in the form of **POTENTIAL ENERGY** or **KINETIC ENERGY** - is able

to do work. That is, its mechanical energy enables that object to apply a force to another object in order to cause it to be displaced.

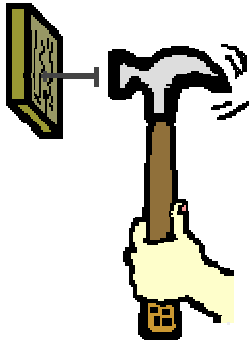
Numerous examples can be given of how an object with mechanical energy can harness that energy in order to apply a force to cause another object to be displaced. A classic example involves the massive wrecking ball of a demolition machine. The wrecking ball is a massive object which is swung backwards to a high position and allowed to swing forward



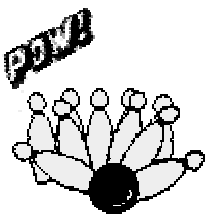
The massive ball of a demolition machine possesses mechanical energy - the ability to do work. When held at a height, it possesses mechanical energy in the form of potential energy. As it falls, it exhibits mechanical energy in the form of kinetic energy. As it strikes the structure to be demolished, it applies a force to displace the structure - i.e., it does work upon the structure.

into building structure or other object in order to demolish it. Upon hitting the structure, the wrecking ball applies a force to it in order to cause the wall of the structure to be displaced. The

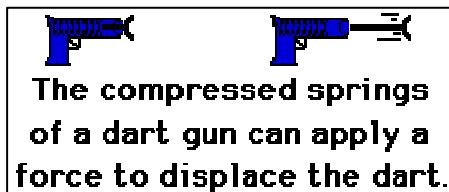
diagram below depicts the process by which the mechanical energy of a wrecking ball can be used to do work.



A hammer is a tool which utilizes mechanical energy to do work. The mechanical energy of a hammer gives the hammer its ability to apply a force to a nail in order to cause it to be displaced. Because the hammer has mechanical energy (in the form of **KINETIC ENERGY**), it is able to do work on the nail. Mechanical energy is the ability to do work.



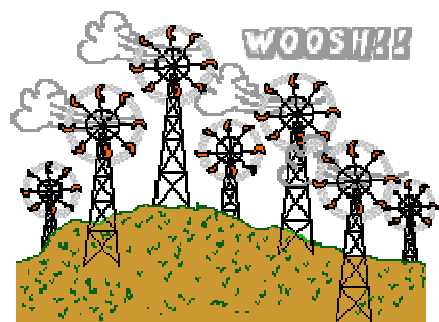
Another example which illustrates how mechanical energy is the ability of an object to do work can be seen any evening at your local bowling alley. The mechanical energy of a bowling ball gives the ball the ability to apply a force to a bowling pin in order to cause it to be displaced. Because the massive ball has mechanical energy (in the form of **KINETIC ENERGY**), it is able to do work on the pin. Mechanical energy is the ability to do work.



A dart gun is still another example of how mechanical energy of an object can do work on another object. When a dart gun is loaded and the springs are compressed, it possesses mechanical energy. The mechanical energy of the compressed springs give the springs the ability to apply a force to the dart in order to cause it to be displaced.

Because of the springs have mechanical energy (in the form of **ELASTIC POTENTIAL ENERGY**), it is able to do work on the dart. Mechanical energy is the ability to do work.

A common scene in the western United States is a "wind farm." High speed winds are used to do work on the blades of a turbine at the so-called wind farm. The mechanical energy of the moving air give the air particles the ability to apply a force and cause a displacement of the blades. As the blades spin, their energy is subsequently converted into electrical energy (a non-mechanical form of energy) and supplied to homes and industries in order to run electrical appliances. Because the moving wind has mechanical energy (in the form of **KINETIC ENERGY**), it is able to do work on the blades. Once more, mechanical energy is the ability to do work.



The kinetic energy of high speed winds contributes to its ability to do work.

As already mentioned, the mechanical energy of an object can be the result of its motion (i.e., **KINETIC ENERGY**) and/or the result of its stored energy of position (i.e., **POTENTIAL**

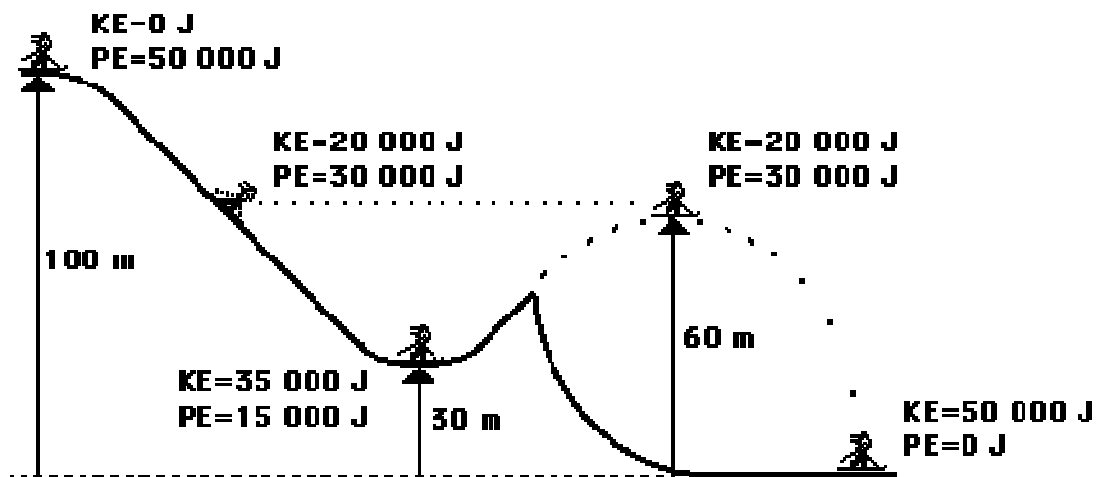
ENERGY). The total amount of mechanical energy is merely the sum of the potential energy and the kinetic energy. This sum is simply referred to as the total mechanical energy (abbreviated TME).

$$\mathbf{TME = PE + KE}$$

As discussed earlier, there are two forms of **POTENTIAL ENERGY** discussed in our course - gravitational potential energy and elastic potential energy. Given this fact, the above equation can be rewritten:

$$\mathbf{TME = PE_{grav} + PE_{spring} + KE}$$

The diagram below depicts the motion of Li Ping Phar (esteemed Chinese ski jumper) as she glides down the hill and makes one of her record-setting jumps.



The total mechanical energy of Li Ping Phar is the sum of the potential and kinetic energies. The two forms of energy sum up to 50000 Joules. Notice also that the total mechanical energy of Li Ping Phar is a constant value throughout her motion. There are conditions under which the total mechanical energy will be a constant value and conditions under which it is a changing value. For now, merely remember that total mechanical energy is the energy possessed by an object due to either its motion or its stored energy of position. The total amount of mechanical energy is merely the sum of these two forms of energy. And finally, an object with mechanical energy is able to do work on another object.