Work, Energy and Power

Questions to make you think

It is estimated that €1 in every €4 spent on energy in Ireland disappears out of poorly-insulated windows, doors and roofs.
What happens to the other €3?

What *is* energy?

Bottom line; nobody *gets* energy because there's nothing to *get*. Energy is not tangible (it is 'an indirectly observed quantity'); you can't hold it in your hand, you can't weigh it on an electronic balance, you can't see it, touch it, smell it etc. Yet when the universe was first created there was a certain amount of this put in to the mix (actually now that I think about it the mix itself was energy (with perhaps just a little dash of time)), and it's all still there today. Its form can change, but the energy itself can't ever disappear.

All right, let's listen to Richard Feynman give his take on it.

There is a fact, or if you wish, a law governing all natural phenomena that are known to date. There is no known exception to this law – it is exact so far as we know. The law is called the conservation of energy. It states that there is a certain quantity, which we call "energy," that does not change in the manifold changes that nature undergoes. That is a most abstract idea, because it is a mathematical principle; it says there is a numerical quantity which does not change when something happens . . . it is a strange fact that when we calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same. It is important to realize that in physics today, we have no knowledge of what energy "is." We do not have a picture that energy comes in little blobs of a definite amount. It is not that way. It . . . does not tell us the mechanism or the reason for the various formulas.
The Feynman Lectures on Physics Vol I, p 4-1

When Feynman wrote,
"It is important to realize that in physics today, we have no knowledge of what energy is," he was recognizing that although we have expressions for various forms of energy from (kinetic, heat, electrical, light, sound etc) we seem to have no idea of what the all-encompassing notion of "energy" *is*.
The various forms of energy ($\frac{1}{2}mv^2$, mgh, $\frac{1}{2}kx^2$, qV,mcT, $\frac{1}{2}I^2$, $\frac{1}{2}CV^2$, etc.) are abstractions not directly observable.
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Now with that interesting bit out of the way, let's go see what we need to know for the exam.

Work is defined as the product of *force* and *displacement*.

Work = Force × displacement*

$$\mathbf{W = F \times s}$$

The unit of work is the Joule (J).

Energy is the ability to do work.

The amount of energy something has is also the amount of work it can do.

Because work is a form of energy it follows that **the unit of energy is also the Joule.**

Work-Energy Principle

The change in the energy of an object is equal to the work done on the object

Different Forms of Energy

Kinetic energy is energy an object has due to its motion.

Formula for kinetic energy:

$$E_K = \frac{1}{2} mv^2 \ *$$

Potential energy is the energy an object has due to its position in a force field.

The formula for potential energy:

$$E_P = mgh$$

Any time work is done energy is transferred*

The Principle of Conservation of Energy*

states that energy cannot be created or destroyed but can only be converted from one form to another.

Loss in Potential Energy = Gain in Kinetic Energy for a freely falling object*

Collisions: Kinetic Energy and Momentum

When two objects collide, momentum is conserved provided no external forces act on the system.

Kinetic energy however is not conserved.

This is because some of the kinetic energy gets converted to sound and heat energy.

Power

Power is the rate at which work is done.

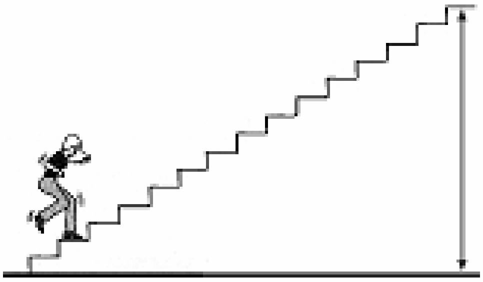
Or

Power is the rate at which energy is converted from one form to another.

The unit of power is **the Watt (W).**

$$\text{Power} = \frac{\text{Work\_Done}}{\text{Time\_Taken}}$$

To estimate the power developed by a person running up a flight of stairs



1. Calculate the work done in going up the stairs.
   This will be the same as your potential energy at the top (mgh), where m is your mass (you will need a bathroom scales).
2. Time how long it takes to run up a flight of stairs.
3. Divide the work by the time taken.

How does your power (kept up for a few seconds) compare with that of a horse over a working day (550 W)?

Did you know that the average brain uses 12 Watts of power (less than a laptop)?
For some of you this may be a bit optimistic.