Lesson 3 Efficiency

Recap

Underneath each graph state the motion of the object shown.

**Velocity**

|  |  |  |  |
| --- | --- | --- | --- |
| A Graphs are pictorial representations of data. In other words, graphs ... | BGraphs are pictorial representations of data. In other words, graphs ... | CGraphs are pictorial representations of data. In other words, graphs ... | DGraphs are pictorial representations of data. In other words, graphs ... |
|  |  |  |  |
| EGraphs are pictorial representations of data. In other words, graphs ...**Velocity** | FGraphs are pictorial representations of data. In other words, graphs ...**Velocity** | GGraphs are pictorial representations of data. In other words, graphs ... | Graphs are pictorial representations of data. In other words, graphs ...**Velocity** |
|  |  |  |  |

Efficiency

Efficiency is a good way to compare devices, as it tells you how much energy is usefully transferred as a proportion of the total energy supplied.

Most energy transfers involve some losses, often by heating.

Principle of conservation of energy tells us that energy cannot be created or destroyed, only transferred. However, energy is only useful when it is transferred from one store to a useful store.

* Useful devices transfer energy from one store to a useful store.
* However, some of the input energy is always dissipated or wasted, often to thermal energy stores of the surroundings.
* Whenever work is done mechanically, frictional forces have to be overcome, including things like moving parts rubbing together, and air resistance. The energy needed to overcome these frictional forces is transferred to the thermal energy stores of whatever’s doing the work and the surroundings.
* This energy usually isn’t useful, and is quickly dissipated.

Example

The diagram shows a motor lifting a load.

The motor transfers energy usefully from its kinetic energy store to the kinetic energy store and the gravitational energy store of the load, but it also transfers energy mechanically to the thermal energy stores of its moving parts, and electrically to the thermal energy stores of its circuits.

The energy is dissipated, heating the surroundings.

\*dissipated just means it is spread out

* The conservation of energy principle means that:
	+ Total energy input = useful energy output + wasted energy

The less energy that is wasted, the more efficient the device is said to be.

Calculating the efficiency of an energy transfer

The efficiency of a device is defined as:

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

All devices have an efficiency, but because some energy is always wasted, the efficiency can never be equal to or higher than 1 (or 100%).

Rearranging the equation

1. Rearrange for useful energy

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

$$useful energy transferred (J)=efficiency x total energy supplied (J)$$

1. Rearrange for total energy

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

$useful energy transferred (J)=efficiency x total energy supplied (J$)

$$total energy supplied \left(J\right)= \frac{useful energy transferred (J)}{efficiency}$$

Worked example 1

A toaster transfers 216,000 J of energy electrically from the mains. 84,000 J of energy is transferred to the bread’s thermal energy store. Calculate the efficiency of the toaster.

Total energy = 216,000 J

Useful energy = 84,000J

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

$$Efficiency= \frac{84000}{216000}=0.39 $$

Worked example 2

An electric motor transfers 100 J of energy. 80 J of this energy is transferred to the kinetic energy store.

Total energy = 100 J

Useful energy = 80 J

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

$$Efficiency= \frac{80}{100}=0.8$$

Worked example 3

A kettle transfers 1000 J of energy electrically from the mains. 400 J of this energy is wasted as sound energy and thermal energy within the cables. This is dissipated to the surroundings. Clauclate the efficiency of the kettle.

Total energy = 1000 J

Wasted energy = 400 J

Total energy = useful energy + wasted energy

1000 J = useful energy + 400 J

Useful energy = 600 J

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

$$Efficiency= \frac{600}{1000}=0.6 $$

Worked example 4

A toaster has an efficiency of 0.75. If 1500 J of electrical energy is transferred to the toaster from the mains electrically, how much energy is useful?

Total energy = 1500 J

Efficiency = 0.75

$$Efficiency= \frac{useful energy transferred by a device (Joules, J)}{total energy supplied to device (Joules, J)}$$

$$useful energy transferred (J)=efficiency x total energy supplied (J)$$

$$useful energy transferred \left(J\right)=0.75 x 1500=1125 J$$

How much energy is wasted?

Useful energy = 1125 J

Total energy = 1500 J

Total energy = useful energy + wasted energy

1500 = 1125 + wasted energy

Wasted energy = 375 J

Questions

**Basic:**

1. **Useful energy out = 100 J**

**Total energy in = 120 J**

1. **Useful energy out = 60 J**

**Total energy in = 240 J**

1. **Useful energy out = 50 J**

**Total energy in = 150 J**

1. **Useful energy out = 2,000 J**

**Total energy in = 4,000 J**

1. **Useful energy out = 117 J**

**Total energy in = 443 J**

**Medium:** (you have to choose what the useful energy is)

1. **An electric Drill uses a total of 160 J and produces 90 J of kinetic energy, 30 J of sound energy and 40 J of heat energy.**
2. **What type of energy is wasted? (can be more than one)**
3. **What type of energy is useful?**
4. **What is the efficiency of the electric drill?**
5. **A hair drier uses a total of 180 J and produces 10 J of sound energy and 170 J of heat energy.**
6. **What type of energy is wasted?**
7. **What type of energy is useful?**
8. **What is the efficiency of the hair drier?**
9. **An electric hob uses a total of 1,500 J and produces 1,300 J of heat energy and 200 J of sound energy.**
10. **What type of energy is wasted?**
11. **What type of energy is useful?**
12. **What is the efficiency of the electric hob?**
13. **A kettle uses a total of 2,500 J and produces 2,200 J of heat energy and 300 J of sound energy.**
14. **What type of energy is wasted?**
15. **What type of energy is useful?**
16. **What is the efficiency of the kettle?**

**Hard:** (you have to re-arrange the equation)

1. **A car engine has an efficiency of 0.25. How much input energy produces 100 J of useful energy?**
2. **A motor has an efficiency of 0.40. How much useful energy is produced from 250 J?**
3. **A hairdryer has an efficiency of 0.80. How much useful energy is produced from 2000 J?**
4. **If a motor with an efficiency of 0.50 is supplied with 30 kJ of energy, how much useful energy is transferred?**

Answers

Recap

A - stationary

B – constant speed

C – acceleration

D - deceleration

E – constant velocity

F - acceleration

G - stationary

H – deceleration

Question answers

**Basic:**

1. **Useful energy out = 100 J**

**Total energy in = 120 J**

$$efficiency=\frac{useful energy}{total energy}= \frac{100}{120}=0.83$$

1. **Useful energy out = 60 J**

**Total energy in = 240 J**

$$efficiency=\frac{useful energy}{total energy}= \frac{60}{240}=0.25$$

1. **Useful energy out = 50 J**

**Total energy in = 150 J**

$$efficiency=\frac{useful energy}{total energy}= \frac{50}{150}=0.33$$

1. **Useful energy out = 2,000 J**

**Total energy in = 4,000 J**

$$efficiency=\frac{useful energy}{total energy}= \frac{2000}{4000}=0.5$$

1. **Useful energy out = 117 J**

**Total energy in = 443 J**

$$efficiency=\frac{useful energy}{total energy}= \frac{117}{443}=0.26$$

**Medium:** (you have to choose what the useful energy is)

1. **An electric Drill uses a total of 160 J and produces 90 J of kinetic energy, 30 J of sound energy and 40 J of heat energy.**
2. **What type of energy is wasted? (can be more than one) sound energy and heat energy**
3. **What type of energy is useful? Kinetic energy**
4. **What is the efficiency of the electric drill?**

$$efficiency=\frac{useful energy}{total energy}= \frac{90}{160}=0.56$$

1. **A hair drier uses a total of 180 J and produces 10 J of sound energy and 170 J of heat energy.**
2. **What type of energy is wasted? Sound energy**
3. **What type of energy is useful? Heat energy**
4. **What is the efficiency of the hair drier?**

$$efficiency=\frac{useful energy}{total energy}= \frac{170}{180}=0.94$$

1. **An electric hob uses a total of 1,500 J and produces 1,300 J of heat energy and 200 J of sound energy.**
2. **What type of energy is wasted? Sound energy**
3. **What type of energy is useful? Heat energy**
4. **What is the efficiency of the electric hob?**

$$efficiency=\frac{useful energy}{total energy}= \frac{1300}{1500}=0.87$$

1. **A kettle uses a total of 2,500 J and produces 2,200 J of heat energy and 300 J of sound energy.**
2. **What type of energy is wasted? Sound energy**
3. **What type of energy is useful? Heat energy**
4. **What is the efficiency of the kettle?**

$$efficiency=\frac{useful energy}{total energy}= \frac{2200}{2500}=0.88$$

**Hard:** (you have to re-arrange the equation)

1. **A car engine has an efficiency of 0.25. How much input energy produces 100 J of useful energy?**

**Efficiency = 0.25**

**Useful energy = 100 J**

$$efficiency=\frac{useful energy}{total energy}$$

$$total energy=\frac{useful energy}{efficiency }= \frac{100}{0.25}=400 J$$

1. **A motor has an efficiency of 0.40. How much useful energy is produced from 250 J?**

**Efficiency = 0.40**

**Total energy = 250 J**

$$efficiency=\frac{useful energy}{total energy}$$

$$useful energy=efficiency x total energy=0.40 x 250=100 J$$

1. **A hairdryer has an efficiency of 0.80. How much useful energy is produced from 2000 J?**

**Efficiency = 0.80**

**Total energy =2000 J**

$$efficiency=\frac{useful energy}{total energy}$$

$$useful energy=efficiency x total energy=0.80 x 2000=1600 J$$

1. **If a motor with an efficiency of 0.50 is supplied with 30 kJ of energy, how much useful energy is transferred?**

**Efficiency = 0.50**

**Total energy = 30kJ = 30,000 J**

$$efficiency=\frac{useful energy}{total energy}$$

$$useful energy=efficiency x total energy=0.50 x 30,000=15,000 J$$