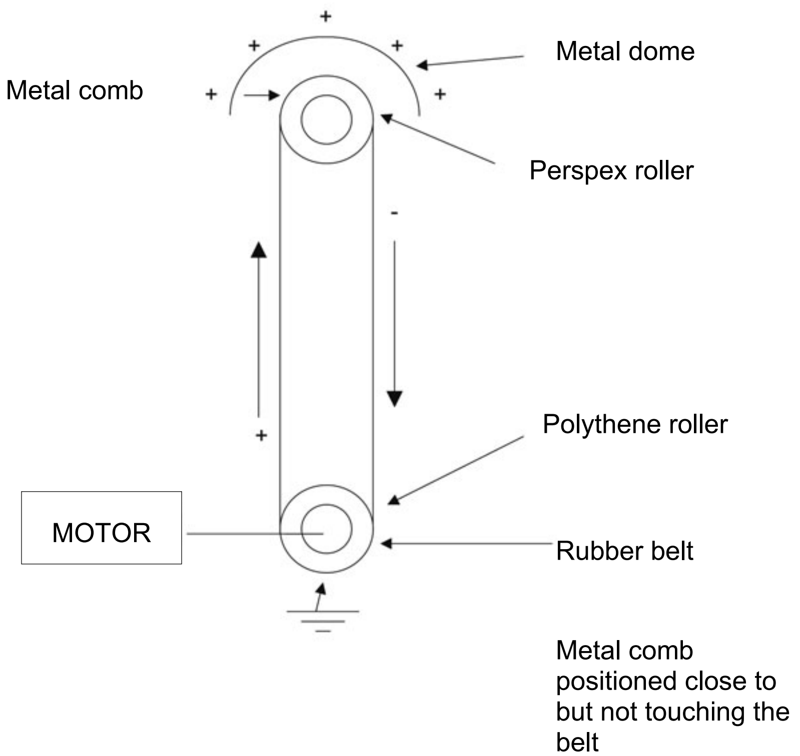
2 Van de Graaff Generator

A Van de Graaff generator is a machine which is used to generate high voltages by charging a large isolated conducting sphere (dome).

Diagram (simplified)



2.1 Operation

Electrons are rubbed off a moving rubber belt at the bottom, leaving the belt positively charged. The belt carries the positive charge to the top. The positively charged belt attracts electrons from the metal sphere, leaving it positively charged. The voltage of the dome increases as the charge builds up.

2.2 Health and Safety

Van de Graaff generators are considered safe, as the currents they produce are well below Health and Safety limits. However, it is wise to take simple precautions when using the generator:

- Always ensure that the dome is discharged after use by earthing it with the smaller discharging dome
- Do not allow people with a heart condition to be used in experiments
- When performing experiments, stand on an insulating mat or plastic tray

2.3 Tips

- In damp/humid conditions use a hairdryer to keep the belt and dome dry
- Check the condition and position of the combs regularly

2.4 Apparatus

2.4.1 Electric Fields

- Van de Graaff generator
- Wire to make electrodes
- Shallow glass dish
- Castor oil
- Semolina grains
- 4mm leads
- 4mm terminals to hold the electrodes (the base of an old switch)

2.4.2 Static Charge Effects: Like Charges Repel

- Van de Graaff generator
- Discharge dome
- A willing volunteer or strands of cotton mounted on a 4mm plug (usually part of the generator kit)
- Insulating stand or sturdy plastic washing up bowl

2.4.3 Gas Discharge

- Van de Graaff generator
- Neon Geissler tube

2.4.4 Balanced Forces

- Van de Graaff generator
- Polystyrene ball covered in gold foil, attached by a thread to a polythene rod. This is normally part of the kit supplied with the generator.

2.4.5 Current as a Flow of Charge

- Van de Graaff generator
- Light beam galvanometer
- Two conducting metal plates with insulating handles
- Polystyrene ball coated in aquadag attached to a length of cotton
- Supporting stands and clamps
- 4mm leads and female connectors to attach leads to the plates. Try not to use crocodile clips.

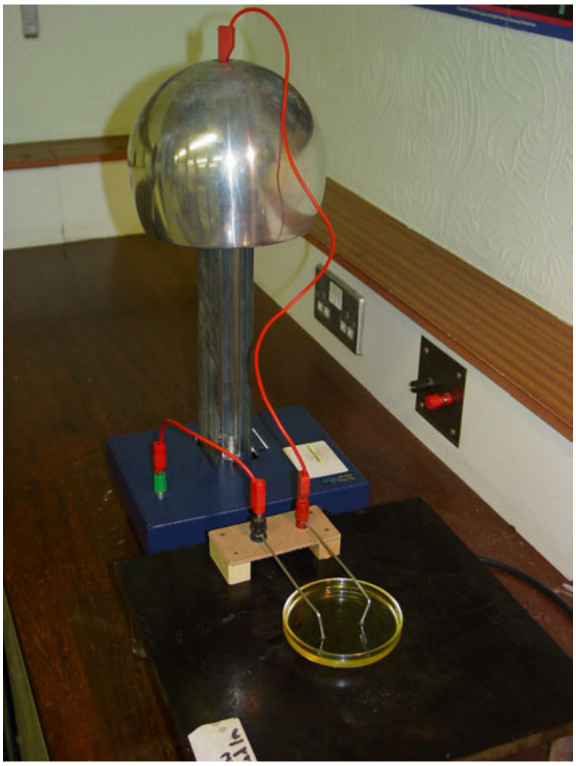
2.5 Electric Fields

An electric field is a region in which a charged particle will experience a force.

In the presence of an electric field, semolina grains will align themselves along the field lines in the direction of the field. The grains become **polarised** and behave as if they had opposite charges at either end. Small pieces of paper become polarised when a statically charged rod is brought close to them, they are then attracted to the rod and picked up.

2.5.1 Setup (not using a manufactured kit)

- Pour some castor oil into a small, shallow glass dish
- Using stiff wire, construct two pairs of electrodes, point and parallel wire. The wires in the photographs were originally part of a coathanger.
- Connect the electrodes to two 4mm terminals. Terminals can either be mounted on a block or an old switch base can be used.
- Connect the dome to one electrode and the Earth connection on the generator (green terminal) to the other. See right.
- Sprinkle the surface of the oil lightly with semolina
- Switch on the generator



Be patient: it will take a few minutes for the grains to align themselves in the field.

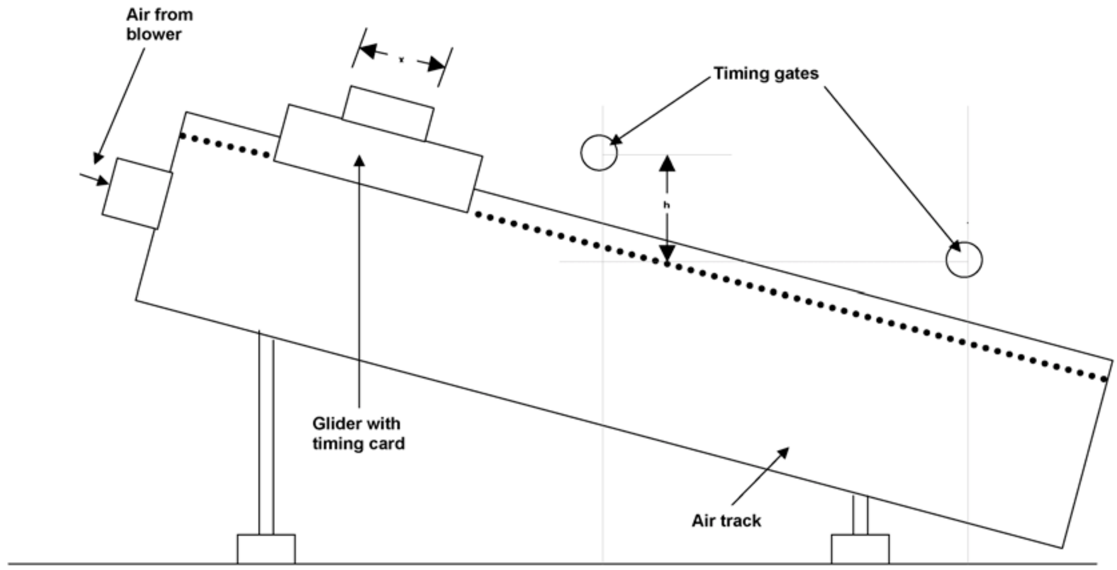
12.5 Demonstration of the Law of Conservation of Energy

The track is set up at an angle so that a glider will accelerate down the track when released, losing potential energy and gaining kinetic energy.

The glider has a timing card attached so that its speed can be calculated as it passes through two timing gates positioned along the track.

12.5.1 Theory

The loss of potential energy of the glider will appear as a gain in its kinetic energy. The air track reduces surface friction to a minimum and very little of the potential energy loss will be transferred to heat.

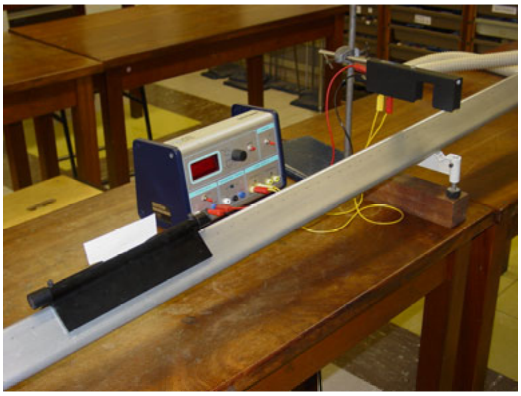


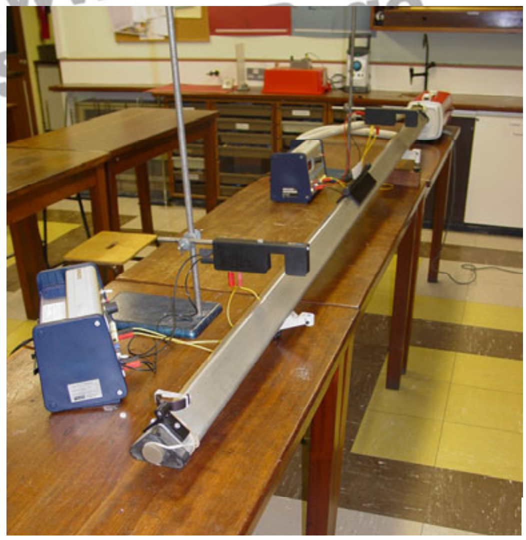
12.5.2 Method

- Set up the apparatus as shown in the diagram.
- Adjust the levelling screw to provide the maximum slope possible or ramp the track with a few pieces of wood.
- Position the timing gates as far apart as possible to allow the maximum fall, h, for the glider.
- Set the timing range on the timers to read to the nearest 0.01 second.
- Switch on the air blower.
- Release the glider from the top of the track and measure the transit times for the glider as it passes through the two timing gates.
- Repeat to check the reliability of the timings.
- Tabulate all results.
- Use a balance to measure the mass of the glider.

- Use a set square and ruler to determine the vertical height drop, h, of the glider between the two gates.

Alternatively, and probably easier, is to raise the track underneath one of the levelling screws with a block of wood of measured thickness. If the timing gates are now positioned directly above the levelling screws, the difficult measurement of **h** is made much simpler.





12.5.3 Typical Results

Mass of the glider,	m =	0.400kg
Length of timing card,	x =	0.100m
Height dropped by the glider,	h =	0.050m
Average time of transit through the top gate,	t_1 =	0.207s
Average time of transit through the bottom gate,	t_2 =	0.091s

g = 9.81N/kg

12.5.4 Calculations

Calculate the speed of the glider as it passes through the two timing gates.

Top gate: Speed, $v_1 = \frac{x}{t_1} = 0.483$m/s

Bottom gate: Speed, $v_2 = \frac{x}{t_2} = 1.099$m/s

Using the equation $E_k = ½ mv^2$, calculate the kinetic energy of the glider as it passes through:

1 the top gate E_k = 0.0467Joules
2 the bottom gate E_k = 0.2420Joules

The **increase** in kinetic energy of the glider = 0.1953Joules

Using the equation E_p = mgh, calculate the **decrease** in potential energy of the glider.

The decrease in potential energy = 0.1962Joules

12.5.5 Conclusion

99% of the potential energy loss has been transferred to kinetic energy, the remainder appearing as heat due to friction.

The law of conservation of energy has been effectively demonstrated.