Space

PERFORM AN INVESTIGATION AND GATHER INFORMATION TO DETERMINE A VALUE FOR ACCELERATION DUE TO GRAVITY USING PENDULUM MOTION OR COMPUTER-ASSISTED TECHNOLOGY AND IDENTIFY REASONS FOR POSSIBLE VARIATIONS FROM THE VALUE 9.8 MS-2

Method:

1. A small mass was attached to one end of a string, and other end of the string attached to a retort stand, such that the string length was 1.0m
2. The mass was pulled sideways to an angle ~10 degrees, and then released.
3. The time for 10 oscillations was measured using a stopwatch.
4. The procedure was repeated 4 more times for a total of 5 trials
5. The procedure was repeated for string lengths of 0.9m, 0.8m, 0.7m, 0.6m and 0.5m

Results:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

- $g = \frac{4\pi^2 l}{T^2}$ Rearranging this equation gives an expression that can be used to calculate ***g***.

- Period-squared was graphed against length of string. The slope of this graph was used to calculate g = 9.87 ms^{-2}

PERFORM A FIRST-HAND INVESTIGATION, GATHER INFORMATION AND ANALYSE DATA TO CALCULATE INITIAL AND FINAL VELOCITY, MAXIMUM HEIGHT REACHED, RANGE AND TIME OF FLIGHT OF A PROJECTILE FOR A RANGE OF SITUATIONS BY USING SIMULATIONS, DATA LOGGERS AND COMPUTER ANALYSIS

Method:

1. A bottle rocket was set up at an angle of 20 degrees from horizontal (measured using protractor)
2. A bicycle pump was used to pump air into the rocket until it took off
3. Flight time was measured with a stopwatch, and range with tape measure
4. Steps 1-3 were repeated for angles of 30, 40, 50, 60, 70 degrees

PERFORM AN INVESTIGATION TO HELP DISTINGUISH BETWEEN NON-INERTIAL AND INERTIAL FRAMES OF REFERENCE

Method:

1. *A vertical accelerometer was held in one hand.
2. Jumped from a 0.5m ledge to the ground, observing the accelerometer sinker's movements
3. A plumb bob was let hang from one hand
4. Its motion was observed when I was standing still, walking with a steady velocity, accelerating to a run, decelerating to a stop, and changing direction

Results:

- Supports Galileo's Principle of Relativity, which states that it is impossible to distinguish between constant velocity and no movement with any mechanical experiment

Motors and Generators

PERFORM A FIRST-HAND INVESTIGATION TO DEMONSTRATE THE MOTOR EFFECT

Method:

1. Two bar magnets were clamped horizontally with opposite poles close together
2. An aluminium strip was suspended vertically between the magnets so that it was free to move, and its ends connected to a power pack
3. The power pack was set to its lowest voltage at DC and turned on
4. Any movement of the aluminium strip was noted
5. The procedure was repeated with magnetic poles reversed, and then with circuit polarity reversed

Results:

- The aluminium strip moved when current was turned on, showing that it experienced a force in the direction stated by the right hand push rule. When magnetic poles or circuit polarity was reversed, the direction of the strip's motion also reversed.
- Hence, the motor effect was demonstrated

PERFORM AN INVESTIGATION TO MODEL THE GENERATION OF AN ELECTRIC CURRENT BY MOVING A MAGNET IN A COIL OR A COIL NEAR A MAGNET

Method:

1. The ends of a solenoid coil were connected to the terminals of a microammeter (diagram)

2. The north pole of a bar magnet was pushed partially into the solenoid coil, and the microammeter's needle movement noted
3. The north pole was pulled out of the solenoid, and the microammeter's needle movement noted.

Results:

- An electric current is produced only when there is a changing magnetic flux, relative motion between magnet and coil

PLAN, CHOOSE EQUIPMENT OR RESOURCES FOR, AND PERFORM A FIRST-HAND INVESTIGATION TO PREDICT AND VERIFY THE EFFECT ON A GENERATED ELECTRIC CURRENT WHEN:
- THE DISTANCE BETWEEN THE COIL AND MAGNET IS VARIED
- THE STRENGTH OF THE MAGNET IS VARIED
- THE RELATIVE MOTION BETWEEN THE COIL AND THE MAGNET IS VARIED

Method:

1. The ends of a solenoid coil were connected to the terminals of a microammeter (diagram)
2. The north pole of a bar magnet was pushed partially into the solenoid coil, and the microammeter's needle movement recorded
3. *Repeat steps 1-2 using a solenoid coil with a larger diameter
4. Repeat steps 1-2 using two magnets held parallel to each other
5. Repeat steps 1-2, except push the magnet in faster

Results:

- Magnitude of generated current:
    - decreases when distance between coil and magnet is increased
    - increases when a stronger magnet (or more magnets) are used
    - increases when the relative motion between coil and magnet is increased
    - increases when the coil has more turns

PLAN, CHOOSE EQUIPMENT OR RESOURCES FOR, AND PERFORM A FIRST-HAND INVESTIGATION TO DEMONSTRATE THE PRODUCTION OF AN ALTERNATING CURRENT

Method:

1. The ends of a solenoid coil were connected to the terminals of a microammeter (diagram)
2. A bar magnet's north pole was moved forward and backward inside the coil in a rhythmic motion
3. The microammeter's reading was observed.
4. The bar magnet was moved faster and the microammeter reading observed

Results:

- Microammeter recorded a current that changed direction as the magnet's movement changed direction
- When the bar magnet was moved faster, the current alternated faster (had a higher frequency)

PERFORM AN INVESTIGATION TO MODEL THE STRUCTURE OF A TRANSFORMER TO DEMONSTRATE HOW SECONDARY VOLTAGE IS PRODUCED

Method:

1. A small primary solenoid coil was placed inside a larger secondary coil.
2. Primary coil was connected to a power pack. Secondary coil was connected to a microammeter
3. The power pack was set to its lowest voltage on DC and turned on. Any microammeter readings were observed, and the power pack turned off.
4. The power pack was set to its lowest voltage on AC and turned on. Any microammeter readings were observed, and the power pack turned off.

Results:

- A DC primary current caused a temporary current in the secondary, which quickly went back to zero
- An AC primary current causes a constant alternating current in the secondary
- Therefore, a secondary voltage is produced only when the current flowing through the primary is changing, and hence the magnetic field through both coils is changing
- When the secondary coil (connected to microammeter) has more turns than the primary coil, the secondary voltage is larger than the primary voltage, and secondary current is smaller than primary current

PERFORM AN INVESTIGATION TO DEMONSTRATE THE PRINCIPLE OF AN AC INDUCTION MOTOR

Method:

1. A bar magnet was suspended horizontally from a length of twisted string, above an aluminium disc balanced on a compass stand
2. The magnet was released so that it rotated about the string's axis
3. Observations of the movement of the aluminium disc were made, and recorded

Results:

- The aluminium disc spun in the same direction as the rotation of the bar magnet. It spun faster when the bar magnet spun faster.

Conclusion:

- The changing magnetic field due to the rotating magnet induced a current in the aluminium disc. By Lenz' law, this current opposed the change in relative motion that caused it. As a result, aluminium disc appeared to 'chase' the spinning magnet.

- The magnet modelled the rotating stator magnetic field in an induction motor. The aluminium disc modelled the rotor.

Ideas to Implementation

PERFORM AN INVESTIGATION AND GATHER FIRST-HAND INFORMATION TO OBSERVE THE OCCURRENCE OF DIFFERENT STRIATION PATTERNS FOR DIFFERENT PRESSURES IN DISCHARGE TUBES

Method:

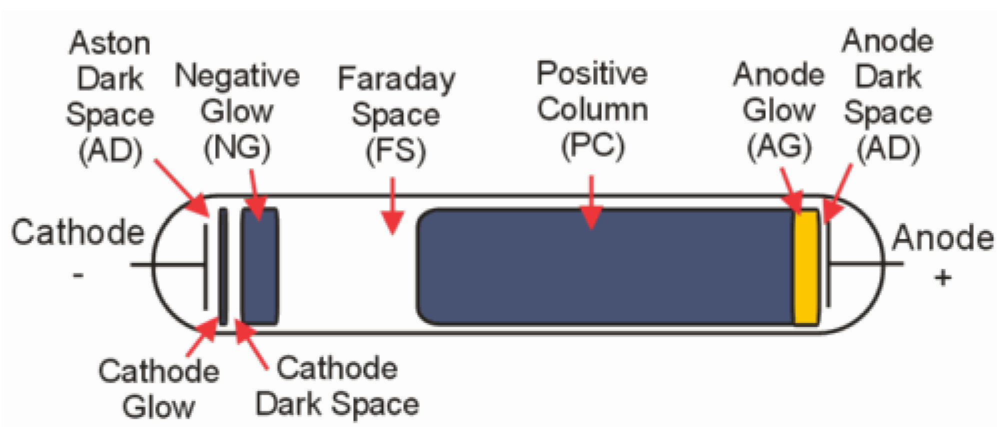
1. An induction coil was connected to the highest pressure discharge tube (40 mmHg), and turned on
2. Any striation patterns were observed and recorded.
3. Steps 1 and 2 were repeated, for discharge tubes with lower pressures (10, 6, 3, 0.14, and 0.03 mmHg)

Results:

- 40 mmHg: large wavering purple streamers
- 10 mmHg: darker violet streamers
- 6 mmHg: softer pink streamer
- 3 mmHg: pink striations perpendicular to the cathode ray (tube length), bands of light and dark; purple glow at cathode/anode
- 0.14 mmHg: magenta streamer
- 0.03 mmHg: faint blue streamer; green glow at anode

Explanation:

- At 0.03 mmHg, pressure is low enough that electrons can travel to the anode and strike the glass, creating a green anode glow

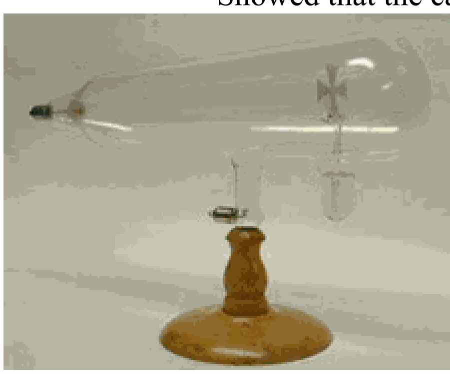
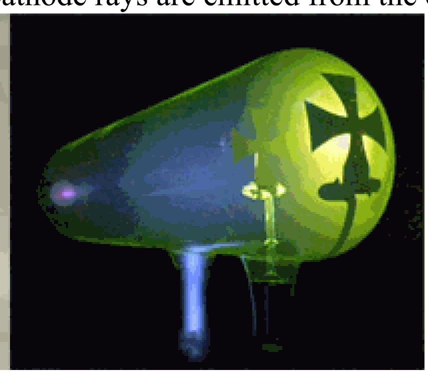


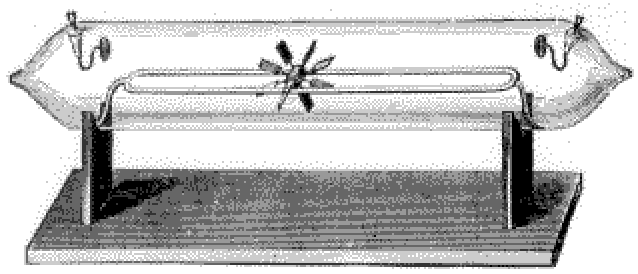
PERFORM AN INVESTIGATION TO DEMONSTRATE AND IDENTIFY PROPERTIES OF CATHODE RAYS USING DISCHARGE TUBES:

- CONTAINING A MALTESE CROSS
- CONTAINING ELECTRIC PLATES
- WITH A FLUORESCENT DISPLAY SCREEN
- CONTAINING A GLASS WHEEL
- ANALYSE THE INFORMATION GATHERED TO DETERMINE THE SIGN OF THE CHARGE ON CATHODE RAYS

Method/Results/Explanation:

1. An induction coil (IC) was connected to a Maltese cross discharge tube and turned on. A clearly defined shadow was observed at the end of the tube.
    - Showed that cathode rays travel in straight lines. While this was offered as evidence that rays were a form of EM radiation like light, it was not conclusive because particles could travel in straight lines too
2. The IC was connected to a discharge tube with oppositely charged electric plates. The cathode ray bent towards the positive plate.
    - Showed that cathode rays were particles, since EM waves could not be deflected by an electric field
    - Since the rays were attracted to the positive plate, they were a composed of negatively charged particles
3. The IC was connected to a discharge tube with a fluorescent display screen. The cathode rays caused the display screen to fluoresce.
    - Showed that cathode rays have transferrable energy
    - *Holding the north pole of a magnet close to the ray caused a deflection associated with negatively charged particles
4. The IC was connected to a discharge tube with a glass paddle wheel. Cathode rays striking the glass wheel made the wheel rotate away from the source.
    - Showed that the rays had transferrable momentum, and therefore mass since p=mv, providing evidence for their particle nature
    - Showed that the cathode rays are emitted from the cathode





PERFORM AN INVESTIGATION TO DEMONSTRATE THE PRODUCTION AND RECEPTION OF RADIO WAVES

Method:

1. An induction coil was connected to a transformer at setting C
2. A portable AM radio was switched on, tuned between stations (so it does not receive a station), and held near the induction coil
3. The induction coil was turned on, and any changes to the radio's sound output was noted
4. Method was repeated, positioning radio at different distances from induction coil, and tuning to different frequencies
5. The radio was relaced with an antenna connected to a CRO. The other end of the antenna was connected to the water tap
6. The induction coil was again turned on, and any changes to the CRO output noted

Results/Explanation:

- The working induction coil caused a disruption signal in the radio (significant increase in crackling and static noise). Therefore, the spark in the induction coil produced radio waves.
- The working induction coil caused an alternating current signal on the antenna. Radio waves from the spark gap excited electrons in the receiver antenna, causing an electrical disturbance. This electrical current was detected by the CRO

PERFORM AN INVESTIGATION TO MODEL THE BEHAVIOUR OF SEMICONDUCTORS, INCLUDING THE CREATION OF A HOLE OR POSITIVE CHARGE ON THE ATOM THAT HAS LOST THE ELECTRON AND THE MOVEMENT OF ELECTRONS AND HOLES IN OPPOSITE DIRECTIONS WHEN AN ELECTRIC FIELD IS APPLIED ACROSS THE SEMICONDUCTOR

Method 1:

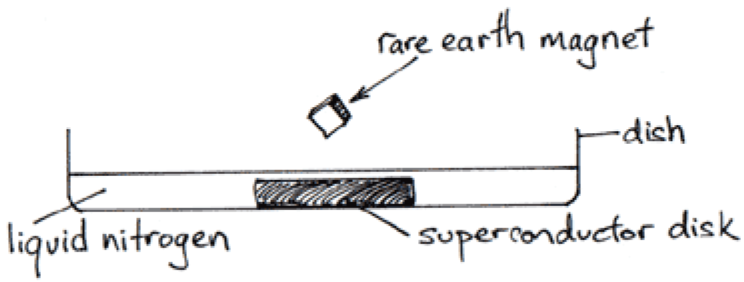
1. *A ball bearing was placed into each of the egg holders in one long side of an egg carton.
    - The ball bearings represent electrons, and this long side of the egg carton represents the valence band.
2. One ball bearing was removed from an egg holder.
    - This represents the creation of a hole on the atom that has lost an electron via doping.

3. One end of the egg carton was raised until a ball bearing fell into the space left by removing the first ball.
    - Raising the carton represents the applied potential difference. The movement of the ball bearing and apparent movement of the empty egg holder represent the movement of electrons and holes in opposite directions when an electric field is applied.

Method 2:

- With people in chairs?

PERFORM AN INVESTIGATION TO DEMONSTRATE MAGNETIC LEVITATION



Astrophysics

IDENTIFY DATA SOURCES, PLAN, CHOOSE EQUIPMENT OR RESOURCES FOR, AND PERFORM AN INVESTIGATION TO DEMONSTRATE WHY IT IS DESIRABLE FOR TELESCOPES TO HAVE A LARGE DIAMETER OBJECTIVE LENS OR MIRROR IN TERMS OF BOTH SENSITIVITY AND RESOLUTION

Method:

1. Circles with diameters of 4, 8, 12, 16, 20 and 24 cm were constructed using strips of paper 1 cm wide.
2. Smarties were placed flat in each circle, so that the base of the circle was covered, and no Smarties overlapped.
3. The number of photons that fit into each circle was counted, and recorded.
4. A graph was drawn of No. of Smarties against diameter, and No. of Smarties against diameter^2

Results/Explanation:

- The circles modelled the diameter of a telescope's mirror. Each Smartie represented a photon
- The graph showed that the number of photons that will fit into a round mirror is directly proportional to the square of the diameter.

- Since sensitivity is a measure of how much light the telescope can collect, a larger mirror provides greater sensitivity.
- Resolution is also improved by larger mirrors, as more photons collected from a single patch of sky means that 2 closer objects in that region can be seen as separate objects.

Method 2:

- Use two binoculars with same magnification but different objective diameters
- Observed a tree far away through both, then a board at the end of a dark hall
- Recorded differences in relative brightness and relative clarity

Method 3:

- For resolution, fill out a table with primary mirror diameters and resolution for different real-world telescopes using Dawe's limit
- Graph resolution against primary mirror diameter

PERFORM A FIRST-HAND INVESTIGATION TO EXAMINE A VARIETY OF SPECTRA PRODUCED BY DISCHARGE TUBES, REFLECTED SUNLIGHT, OR INCANDESCENT FILAMENTS

Method:

1. A spectroscope was used to observe a working hydrogen discharge tube in a dark room
    - The discharge tube produces an emission spectrum, with a few bright lines against a black background.
2. The spectroscope was used to observe the spectrum of sunlight reflected from a sheet of white paper
    - The sun produces a continuous spectrum, with dark absorption lines
3. The spectroscope was used to observe the light produced by an incandescent light bulb
    - Incandescent light bulbs produce a continuous 'rainbow' spectrum

PERFORM AN INVESTIGATION TO DEMONSTRATE THE USE OF FILTERS FOR PHOTOMETRIC MEASUREMENTS

Method:

1. A light ray box was set up at a fixed distance from a light meter. The room was darkened
2. A red filter was placed in front of the light ray to simulate a red star.
3. The light meter was covered with a blue filter, and the intensity of light received at the light meter was recorded.
4. Previous step was repeated, covering the light meter with a red filter and a yellow filter
5. The red filter in front of the light ray was replaced with a blue filter to simulate a blue star, and all previous steps were repeated.
6. The brightness of the 'red star' and 'blue star' through different filters was compared

PERFORM AN INVESTIGATION TO MODEL THE LIGHT CURVES OF ECLIPSING BINARIES USING COMPUTER SIMULATION

http://laserstars.org/glossary/binary.html

- Investigated how shape of light curve varies with stars' luminosities, masses, and radii
- Relative drops of primary minimum and secondary minimum tell us relative luminosities of both stars
- If one star has a significantly larger radius than the other, the light curve is flat at the minima as eclipses continue for a longer time. If both stars have about equal radii, the minima are sharper as eclipses end quickly.
- When the plane of the orbit is inclined at an angle to our line of sight, minima are sharper. Eclipses may not occur if the angle of inclination is too large.
- If the orbits are highly eccentric, time-spacing between consecutive minima will be very different.