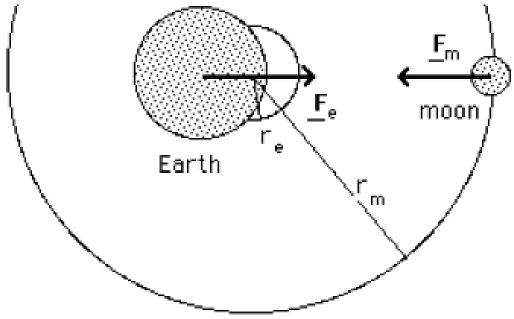
06 Fields and forces review answers

Part A: Gravitational

1. Calculate the average force of attraction between the Earth and the moon. [M_e = 6.0x10^{24} kg, mm = 7.3 x 10^{22}kg, Average distance from the Earth to the Moon is 3.8x10^{8}m].
   Use **$F = GMm/r^2$**



2. Derive the formula for gravitational field strength at a planet based on all the mass being concentrated at the centre of the planet.
   Combine GMm/r^2 and $g = F/m$ to get $g= GM/r^2$
3. Calculate the gravitational field strength at the surface of the moon (diameter 3500km).
   Use **$g= GM/r^2$**
4. Calculate the gravitational field strength due to the moon and the Earth at a point 3.8x10^{7}m from the moon in a direction directly towards the Earth.
   Use **$g= GM/r^2$ for the moon and then for the Earth. The overall field strength is these two subtracted because they are in opposite directions. Overall field strength should be very small the attraction of the Earth and Moon cancel at this point.**

Part B: Electric:

1. The positive parts of the molecules of most solids cannot be transferred when rubbed with a cloth. Explain how it is possible for a material to become positively charged. What charge will the cloth have in this case? **Cloth could have removed electrons from the solid so would be negatively charged.**
2. The dome of a Van de Graaf generator contains 10x10^{25} atoms. It is made from Iron (atomic number = 26) and is charged with a negative charge of 10 Coulombs.
   a. How many electrons would be transferred if the dome was discharged?
      $10\ C \div 1.6 \times 10^{-19}\ Ce^{-1} = 6.25 \times 10^{19}\ e$
   b. What is this as a percentage of the total electrons on the dome.
      Iron has 26 electrons on each atom (10x10^{25}) so 2.6x10^{27} electrons on dome.
   c. The dome is almost spherical and charge is added from the inside of the dome by a belt that runs through the base of the dome. Explain why the electrons already on the dome do not prevent more electrons being transferred.
      The field inside a conducting sphere is zero because the electrons repel each other and are distributed equally onto the sphere.

3. State Coulombs law and apply it to this situation:
Two paint droplets are both charged with +5mC. If they are 1mm apart what force is acting between them?

4. Electric field strength can be given in Vm^{-1} or NC^{-1}. Using the definition of voltage and work done show that these units are equivalent.

5. Electrical potential difference is defined as the work done per unit charge in moving a charge between two points in an electric field. If a positive charged is moved towards a positive charge is it gaining or losing electrical potential energy?

6. A +5mC paint droplet is sprayed into an electric field between a car door charged at -200V and a plate 0.5 metres from the door charged at +200V.
(a) What is the Electric field strength in between the plate and the door?
(b) How much force will there be from this field on the droplet?
(c) How much electrical potential energy will the droplets lose as it travels from the middle of the field onto the door?

3. Use $F = kqq/r^2 = 8.99\times10^9\ Nm^2C^{-2} \times 5\times10^{-3}C \times 5\times10^{-3}C/(1\times10^{-3}m)^2 = 2.25\times10^8\ N$

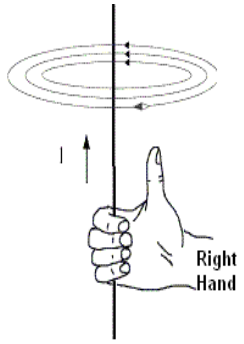
4. Voltage (Electric potential) is work done to bring a unit charge from infinity to its poitision and is therefore equal to the electric potential energy per unit charge [JC^{-1}]. So [Vm^{-1}] is [$JC^{-1}m^{-1}$].
Work done is energy transferred so is measured in [J] but work done can be calculated by Force x Distance moved [Nm]. Therefore [$N\ C^{-1}$] = [$JC^{-1}m^{-1}$]. (Other explanations are possible).

5. If a positive charge moves towards a positive charge work is done on it so energy is transferred to it so it is gaining electrical potential energy. (It has the potential to fly away from the positive charge).

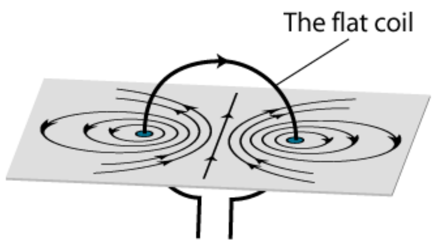
6. (a) $E = -\Delta V/\Delta x = -400V/0.5m = 800Vm^{-1}$ or NC^{-1}.
(b) $E = F/q$ so $F = Eq = 800NC^{-1} \times 5\times10^{-3}C = 4N$
(c) EPE loss is ΔE: $\Delta V = \Delta E/q$ so $\Delta E = \Delta V \times q = 200\ V \times 5\times10^{-3}\ C = 1J$ [$V=JC^{-1}$]

<u>Part B: Magnetic:</u>

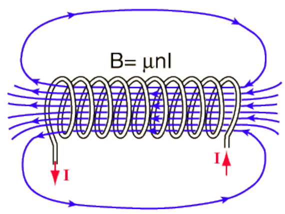
1. Draw the magnetic field patterns due to electric currents in a straight wire, a flat circular coil and a solenoid.



Magnetic field "curls" in direction around the wire as shown



Magnetic field pattern generated by a flat coil



The magnetic field is concentrated into a nearly uniform field in the center of a long solenoid. The field outside is weak and divergent.

2. Look at the diagram opposite
   a. Determine the direction of the force on the wire due to the interaction of its magnetic field and the magnets.
   Using Fleming's left hand rule force will be out of the page.
   b. If the field strength in between the magnets is 0.2T and approximately 0.1m of wire is affected by the field calculate the size of the force for a current of 2.5A.
   $F = BIv = 0.2 \times 0.1 \times 2.5 = 0.05N$