Electricity and Magnetism Semiconducting At very low Electric currents in The interplay of electric The nuclear forces that materials differ greatly temperatures, some the Earth's interior and magnetic forces is in how well they materials become the basis for many hold the protons and give the Earth an Electric forces hold conduct electrons superconductors extensive magnetic modern technologies neutrons in the nucleus solid and liquid of an atom together are depending on the and offer no field, which we detect including electric motors, materials together and resistance to the much stronger than the exact composition of from the orientation generators, and devices act between objects electric forces between the material. flow of electrons. of compass needles. that produce or receive when they are in electromagnetic waves. the protons and contact as in sticking electrons of the atom. or sliding friction. That is why much In many conducting greater amounts of Most materials have materials, such as metals, some of the electrons are not energy are released equal numbers of When electrically Magnetic forces are from nuclear reactions protons and electrons firmly held by the nuclei of the charged objects than from chemical very closely related to and are therefore atoms that make up the undergo a electric forces and are reactions. electrically neutral. In material. In these materials, change in thought of as different At the atomic most cases, a material applied electric forces can motion, they aspects of a single level, electric acquires a negative cause the electrons to move produce electromagnetic force forces between charge by gaining through the material electromagnetic Moving electrically electrons and Electric forces acting producing an electric current. electrons and acquires waves around charged objects protons in atoms within and between In insulating materials, such a positive charge by them hold molecules produces magnetic atoms are vastly as glass, the electrons are losing electrons. Even a forces and moving together and thus stronger than the tiny imbalance in the held more firmly, making it magnets produces are involved in all gravitational forces number of protons and nearly impossible to produce electric forces. chemical acting between the electrons in an object an electric current in those atoms. At larger reactions can produce noticeable materials. scales, gravitational electric forces on other forces accumulate to objects. produce a large and The motion of electrons is far noticeable effect more affected by electrical whereas electric forces Atoms are made of a positively forces than protons are tend to cancel each charged nucleus surrounded by because electrons are much other out. negatively charged electrons. The less massive and are outside of the nucleus nucleus is a tiny fraction of the volume of an atom but makes up almost all of its mass. The nucleus The change in motion (direction or is composed of protons and neutrons which have roughly the speed) of an object is proportional to the applied force and inversely same mass, but differ in that protons are positively charged while proportional to the mass. neutrons have no electric charge **Laws of Motion** Electrical circuits require a complete loop through which an electrical current can pass. ① Electric circuits Materials vary in how they An unbalanced force respond to electric currents, acting on an object A charged object can be charged magnetic forces, and visible changes its speed or in one of two ways, which we call light or other either positively charged or negatively charged. Two objects direction of motion, electromagnetic waves. or both. Forces without contact ① Making a change that are charged in the same manner exert a force of repulsion Laws of Motion Gravity on each other, while oppositely charged objects exert a force of attraction on each other. Electrostatics Changes in speed or direction of motion are caused by forces. Making a change Making a change Without touching them, a Without touching them, an Gravity magnet pulls on all things object that has been made of iron and either electrically charged pulls on pushes or pulls on other all other uncharged objects magnets. and may either push or pull Forces without contact other charged objects. Electrostatics The way to change how something is moving is to give it a push or pull. Magnets can be ① Pushes & pulls used to make some **①** What is a force? things move without Gravity being touched. Laws of Motion effects at the atomic level electric charge electric currents electromagnetism