EEE 3112 Electrical Engineering Practice

Lecture 1: Occupational health and safety

0. Revisit Course Outline

1. Occupational health and Safety: Risk definitions: hazard, danger, damage, risk, Accidents, Risk perception, Hazard control and design
2. Ohm's law: Insulators and conductors, Health effects, AC and DC circuits
3. Branch circuits: Wiring methods/plugs and receptacles, polarity, Grounding
4. Circuit and equipment testing: Testing branch circuits, Receptacles, Extension cords, Plug and cord- connected equipment, Voltage detectors
5. Ground Fault Circuit Interrupters (GFCI's): Theory, GFCI Configurations, Applications
6. Flammable/Combustible Materials (Hazardous Locations): Combustion and explosions, Electrical ignition sources, controlling ignition hazards.
7. Electrical lockout/tag out: Definitions and standards, Permit systems Need for hazardous energy control, Written program, Training. Standards/Common electrical deficiencies.

8. Electrical Drawing: Graphical symbols. Various types of diagram; examples from electronic and power equipment, and power systems. Views and sections of some items of electrical equipment.

ASSIGNMENT 1

1. Write brief notes on what you understand about occupational health and safety

2. What are conductors and insulators?

3. What are the health effects related to AC and DC circuits?

1. Health Effects

- From time to time magazine or newspaper articles appear on possible health effects to people that live near transmission lines or high voltage workers.

- The 50 Hz electric and magnetic field limits set by ICNIRP are shown in the table below:

Maximum allowed field strength levels

EXPOSURE	E-FIELD [kV/m]	H-FIELD [uT]
OCCUPATIONAL	10	500
PUBLIC	5	100

- These limits are for 50/60 Hz time varying fields.

- The electric and magnetic field effects of DC lines on humans are much less, but adherence to the above limits is advisable.

2. Safety and Electrostatic Hazards

- The early Greeks, 600 BC, noticed that amber, when rubbed, could attract light objects.
- They were responsible for the term “electricity” derived from their word for amber.
- They spent many hours rubbing a small piece of amber on their sleeves and observing how it would then attract pieces of fluff and stuff.
- Static electricity affects many industries and diverse environments.
- The results of static charge build up are quite noticeable, e.g., lightning.

- These results include potentially dangerous electrical shocks which can cause decreases in productivity, machinery jams, fires, and explosions.

- Static electricity can also cause severe damage to sensitive electronic components, requiring costly repair.

2.1 Nature of Static Electricity

- Static electricity is an electrical charge at rest, it is generated by unbalancing the molecular construction of relatively nonconductive insulators such as plastic and paper.

- To understand what static electricity is, we have to learn a little bit about the nature of matter.

- The majority of electrostatic charges are caused by two different materials being rubbed together.

- Static electricity can also be generated by friction, pressure, and separation.

- Friction causes heat which excites the molecular particles of the material.

- When two materials are separated, a transfer of electrons from one material to the other may take place.
- As electrons transfer, the absence or surplus of electrons creates an electric field.
- Static electricity can also be generated by rupture of the molecular structure caused by cutting, slitting, and tearing.

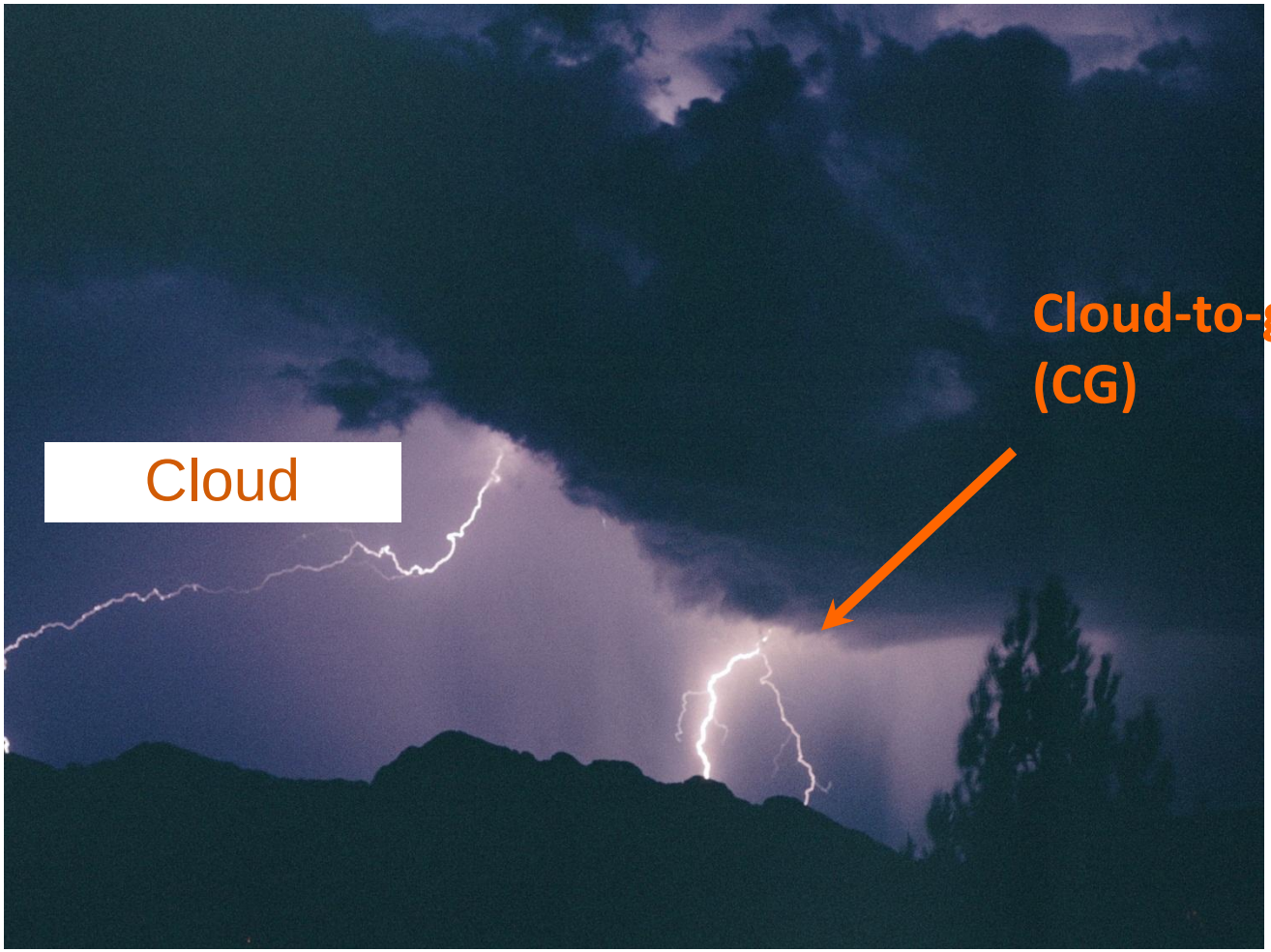
- It can also be generated by rapid temperature change, radioactive emission, and chemical changes in a material.

- These processes give rise to imbalance between positive and negative ions on the surface of the material.

- Lightning is a manifestation of static electricity. Masses of air rise and fall during thunderstorms. They rub against rain clouds, which causes them to become electrically charged. Lightning occurs when objects of different charges get close to each other.

- The amount of static electricity generated depends upon the materials subjected to friction or separation, the amount of friction or separation, and the relative humidity of the environment.

2.1.1 Two categories of lightning



Cloud-to-ground flash

Unsuccessful downward leaders

Preferred strike points
- **Tall**
- **Isolated**
- **Pointed**

Main channel

Upward leader

Lightning in parking lot

2.2 Man's Common Activities and the Voltages Generated

Means of Generation	Electrostatic Voltage [kV]		
	Relative Humidity		
	10%	40%	55%
Person Walking across a carpet	35	15	7.5
Person Walking across a Vinyl tile	12	5	0.3
Worker at a Bench	6	0.5	0.4
Ceramic Dips in Plastic Tube	2	0.7	0.4
Ceramic Dips in Styrofoam	14.5	5	3.5
Circuit Packs as Bubble Plastic Cover is Removed	26	20	7

2.3 Electrostatic Discharges (ESD)

- ESD is the transfer of charge between bodies at different electrical potentials.

- It arises when a static charge accumulates on a nonconducting object and then finds a path to ground.

- Once a person is charged, and depending on the relative humidity, a discharge will occur if the person touches a surface at a lower potential.

- There are many industries and commercial operations where electrostatic phenomena are either exploited to achieve useful ends or dealt with as a nuisance or hazard to be avoided.

2.4 Hazards of Electrostatic Electricity in Industry

- Some industries are very sensitive to ESD even at a few hundred volts, such as the petroleum and chemical industries.

- Other industries and activities such as textile, fertilizer, paper, rubber, wheat flour, grain transportation, hospitals, etc, suffer from ESD and strict measures should be taken to eliminate, or reduce to an acceptable level, the accumulation of static charges.

2.4.1 Grain Transportation

- Grain such as wheat is transported by either pipes or conveyor belts.
- When transported by pipe, the relative motion of the grain to the pipe walls causes friction and hence electrostatic charges are generated on the grain.
- As the grain continues to flow along the pipe it acquires more and more charges.
- The amount of charge acquired by the grain particles depends on their flow speed, surface area, and charge leakage.
- If the charge builds up on the grain particles such that the electric field between them and the pipe walls exceeds the withstand flashover voltage of the ambient, a spark will develop.
- This spark may lead to explosion of the transportation system and injuries to nearby personnel.

- Conveyor belts are also used in grain industries such as grain elevators.

- In these industries the atmospheric air is contaminated with fine dust particles which are highly explosive when subjected to ESD of sufficient energy.

- ESD can start from the conveyor belt itself as a result of friction between the belt and grain particles.

- Or ESD can start from the workers walking around and generating electrostatic charges by friction with the floor.

- Under some favorable conditions the charge accumulated on a worker is enough to initiate a spark when touching a metallic casing or machine.

2.4.2 Chemical Industries

- Chemical industry facilities such as fertilizer factories suffer from fires and explosions due to static charges unless they are properly protected.

- The final chemical product usually passes through several industrial processes: crushing, grinding, pulverizing, mixing, and belt or pipe transportation.

- Many of the elements of the chemical products are volatile and flammable.
- Also, tiny dust particles possess static charges and their accumulation on metallic parts may cause ESD.
- In some cases, in dry atmosphere, minute sparks may occur between the particles themselves, leading to explosion or fire.

- In some industries humidification of the ambient may be a solution to reduction of static charges, but in most chemical processes increased humidity has an adverse effect on the quality of the product.

- In chemical industries strict measures should be taken to avoid ESD. Among these measures are bonding and earthing of all metal parts, cleaning the accumulated dust by vacuum cleaner rather than blowing as this aggravates the problem.

- Blowing air at high speed at the dust particles increases the static charges on the particles and metal surfaces.

- Covering the floor with antistatic material is an additional protective measure.

2.4.3 Hazards from Electrical Equipment and Installations

STATIC CHARGES IN POWER TRANSFORMER

- Transformers are major elements in power plants and the possibility of their damage and outage is of paramount concern for continuity of supply and avoidance of long repair and maintenance times.

- Large power transformers are cooled by pumping away hot oil at the top of the tank, through pipes to radiators, and then back to the tank.

- During oil flow, the oil generates static charges by friction with iron core, pipes, and radiator. Under some conditions sparks may develop inside or outside the transformer.

- If these sparks occur frequently, damage and degradation of the winding and oil will occur, leading to transformer outage.

- To reduce static charge accumulation in transformers and the cooling system, good earthing of core, tank, and piping system is a major factor.

HAZARDS FROM HV POWER LINES

- Farmers, animals, plants, pipelines, fences, and vehicles are subjected to various effects in the vicinity of power lines.

- These effects could result from capacitive, inductive, and conductive coupling between the power line and other objects.

3. Analogy between electric and gravitational forces

- The electric (Coulomb's Law) and gravitational forces have similar forms:

$$F = -k\frac{q_a q_b}{r^2} \qquad F = -G\frac{M_a M_b}{r^2}$$

- Note that gravitational forces are always attractive (*F* is always negative), while the electric force is attractive for opposite and repulsive for like charges.

- Also notice that the electric force is **MUCH** stronger: $k = 8.99\times10^{9}\ \text{Nm}^2/\text{C}^2$ whereas $G = 6.67\times10^{-11}\ \text{Nm}^2/\text{kg}^2$

End of lecture!