EIE512 – Lecture Six

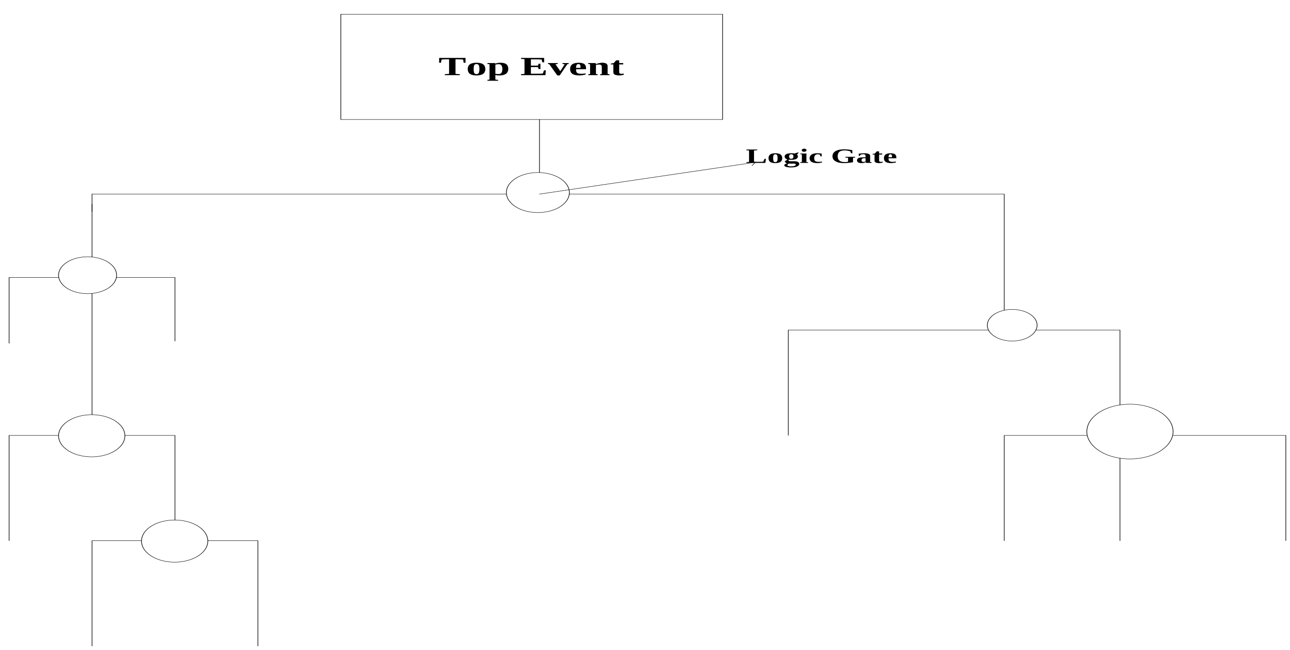
Fault Tree Analysis

All entries are fault of failure mode

It looks for a particular failure mode which may be caused by other failure modes e.g. car overloading, fan belt, low water level

Basic cause of failures are placed at the bottom of the tree

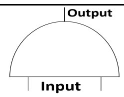
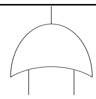
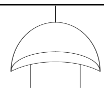
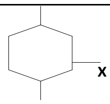
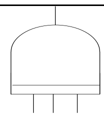
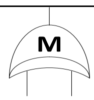
For the various causes, look for the causes of these!



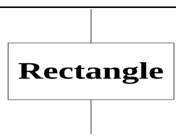
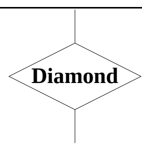
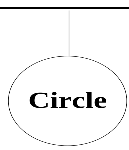
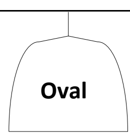
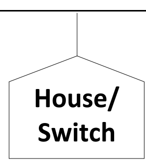
- Analysis is from bottom to top
- Can be qualitative or quantitative
- Twin of FMCEA

Gate symbol

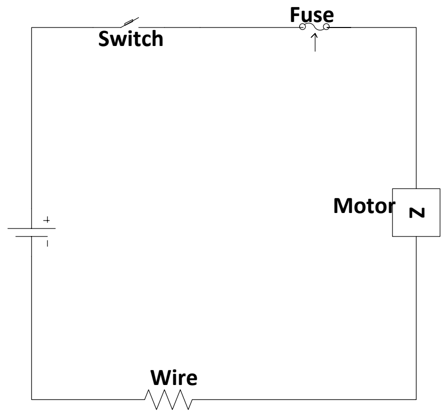
Gate Symbol	Name	Causal Relationship

	AND	If the two input event failure occur simultaneously, the output will occur.
	OR	Output occur if only one of the input occur Note: Inputs are the causes of failure.
	XOR	Both failures cannot occur. Just one.
	INHIBIT	Conditional gate. Output occurs upon the condition that ‘x’ condition occurs.
	Priority AND	The input must occur in a particular sequence for the output to occur
	M-out-of-N	Certain number of failure must occur for event/failure to occur. Special OR-Gate

Event Symbols

Symbol/Name	**Event**
	Combination event
	Secondary event
	Primary event
	Conditional event
	It has two state, either ON or OFF

Example



The motor will overheat (top event) if there is primary motor failure or there is excessive current in the motor. Excessive current to the motor occurs if there is excessive current in the circuit and the fuse fails to open. Excessive current in the circuit occur if there is primary power failure or there is wiring failure. The fuse will fail to open if the is primary fuse failure.

Probability of primary motor fail = 0.03

Probability of wiring failure = 0.01

Probability of power failure 0.05

Probability of fuse failure = 0.02.

Use fault tree analysis to determine the probability of the motor overheating.

Solution:

- OR – Series
- AND – Parallel

P[excessive Current] = {(0.05 + 0.01) – (0.05)(0.01)} = 0.0595

P[excessive motor current] = {(0.0595)(0.02)} = ?

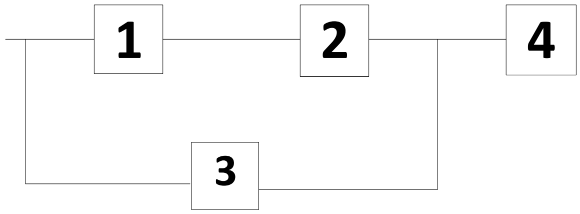
P[motor overheat] = {(0.03 + 0.0119) – (0.03)(0.0119)} = ?

CUT SET

- A cut set is a collection of basic event such that if all basic events in the cut set occur, then the top event is guaranteed to occur.
- A cut set disconnect the input from output

Minimal Cut Set

- If any basic event is removed from the minimal cut set, then the remaining event will collectively no longer hold for a cut set
- Minimal cut set define a general failure mode and its used to simplify fault tree analysis.

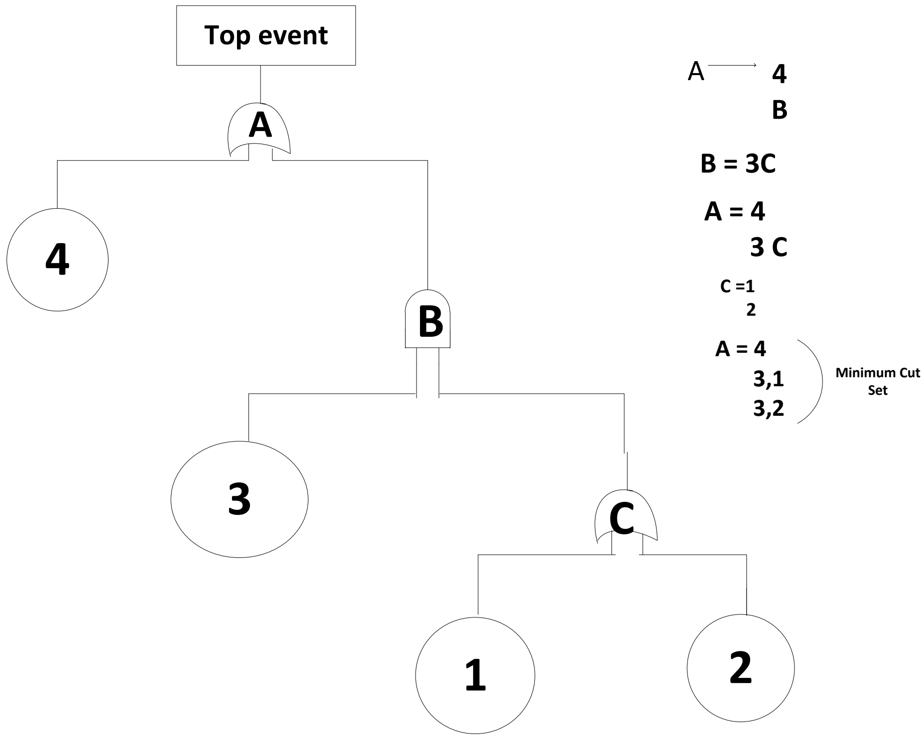


{1,3}, {2,3}, {4} minimal cut set

Method of Obtaining Cut Set.

1) **M**ethod of **O**btaining **Cu**t **S**et (Mocus Method)

- Starting from the top-most gate. If event is an OR-gate, go vertical. AND-gate, then go horizontal.



2) Boolean Algebra

A = 4 + B

A = 4 + (3.C)

A = 4 + [3.(1 + 2)]

A = 4 + 3.1 + 3.2

3) **Mi**nimal **C**ut **S**et **Up**ward (MISCUP)

C = 1 + 2

B = 3.C

B = 3.(1 + 2)

A = 4 + B = 4 + 3.1 + 3.2 Minimum Cut Set

4) Matrix Form

$$A = \begin{pmatrix} 4 \\ B \end{pmatrix}$$

B = 3.C

$$A = \begin{pmatrix} 4 & \\ 3 & C \end{pmatrix} = \begin{pmatrix} 4 & \\ 3 & 1 \\ 3 & 1 \end{pmatrix}$$

PART COUNT ANALYSIS

- Reliability prediction technique
- Can estimate reliability from design of product
- Not accurate but give insight into reliability.

Principle of Part Count Analysis

Each part of a system contribute to the overall reliability

The more complex a system is, the more difficult it is to analyze

The component work independently

Compute failure rate and add overall

If any part fails, it will lead to the overall failure

The system operate under CFR (exponential distribution)

It is used at the initial stage of the product.

$$\lambda_{equipment} = \sum_{i=1}^{n} N_i \lambda_{gi} \pi_{Qi}$$

n = number of category of similar component. E.g. Transistor classified low or high power.

N_i = Total categories (Nth category)

λ_{gi}= Generic λ value (Obtained from the **Mil**itary **St**andar**d** Database)

π_{Qi} = Part quality parameter (Mil-std handbook)

Other sources of data for λ_g

- Offshore reliability data handbook (OREDA)
- Defense Standard 00-0041 (Part 3)
- Reliability and maintainability in perspective

Component/Part	**No. of Parts**	**λ_g (10^{-6}/hour) F-Rate**	**Total Failure (10^{-6}/hour)**
RF Power Transistor (NPN & Silicon)	4	0.042	0.168
Medium power transistor (NPN & Silicon)	2	0.0043	0.086
Low power transistor (NPN)	1	0.056	0.056
Zener diode (silicon)	1	0.011	0.011
Resistor 0.1	3	0.0115	0.0345
Resistor	5	0.0323	0.1615
Capacitor	2	0.054	0.1080
Variable Resistor	1	0.9	0.9
n = 8	19	?	?

Part Stress Analysis

- Takes into consideration temperature, pressure, stress etc
- Expected to be more accurate
- It is implemented at the final design stage.
- More complex

$\lambda_p = \lambda_b \pi_Q \pi_E \pi_A$ ...

λ_p = Failure rate of each part category

λ_b = Base Failure rate (temperature dependent)

π_Q = Path quality parameter

π_E = Environment

π_A = Application Stress, where applicable