

# Synopsis Presentation on

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## **"FRACTURE-FATIGUE SIMULATION USING MESHFREE METHODS"**

You are requested to please give your valuable Criticism/suggestions/ comments. You may use the contents but please send me a copy of your presentation.

Prepared

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# Introduction



**The order of presentation is as hereunder:**

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Fracture

Fatigue

Simulation

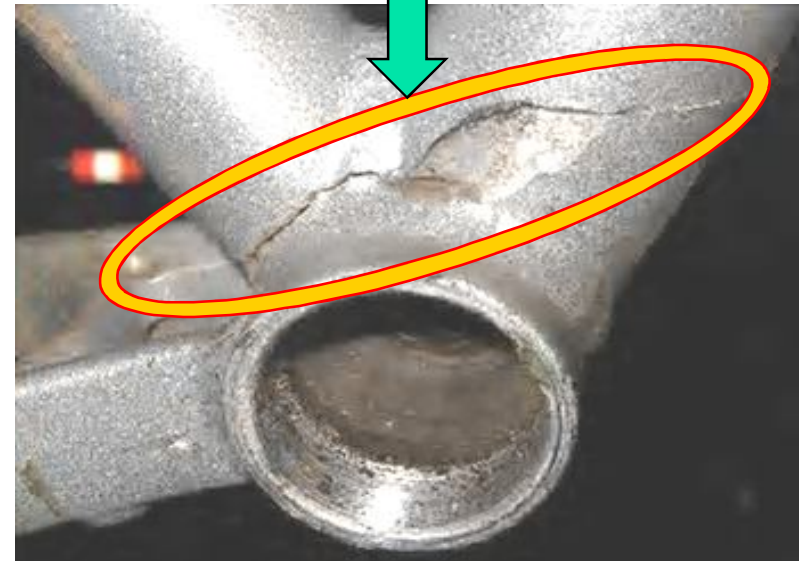
Objectives of the research work?

Meshfree methods: A tool for simulation

# Fracture

- ❖ Fracture is the mere breakage of a body into two or more pieces.
- ❖ Fracture starts with a **crack OR Cracking**: to **break without making fully apart**, to break in such a way that a fine split or splits appear but the split sections do not come apart.

*Crack in a  
bicycle frame*



- ❖ Fracture takes place whenever the applied stresses are more than the resisting strength of the body.

# Fracture (Cont'd)

## Three Modes of Cracking

### Cracking

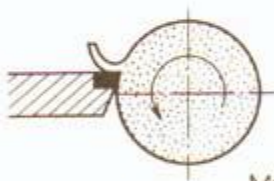


Mode I

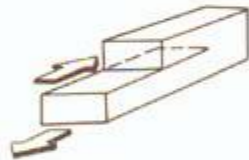


**Mode I** Opening mode

**Mode II** In-plane shearing/sliding mode



Mode II



**Mode III** Out-of-plane shearing/tearing mode



Mode III

**We shall mostly deal with Mode I in this research work**

# Fracture (Cont'd)

## Types of Fracture

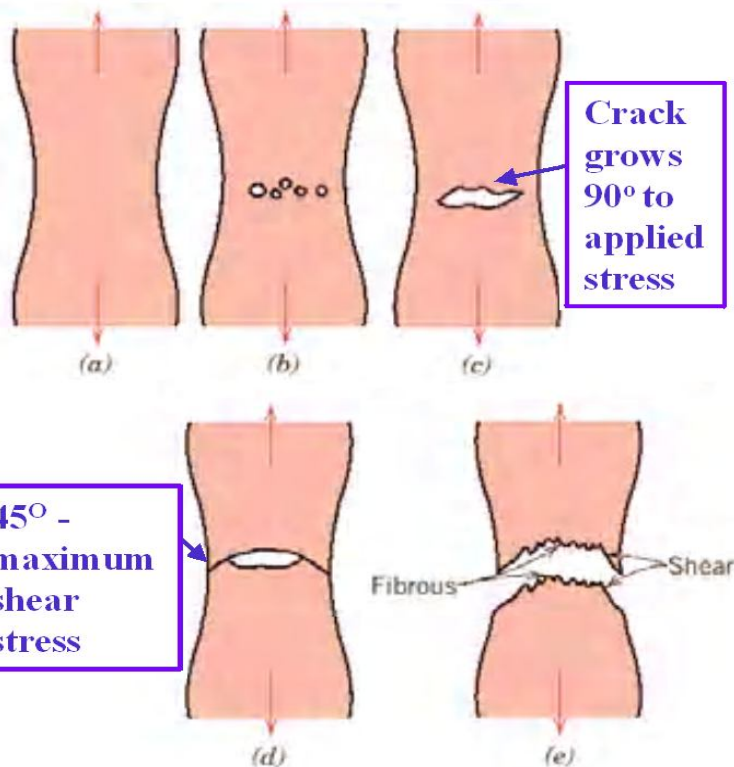
Ductile

Brittle

Creep

Fatigue fracture

### Ductile Fracture



- (a) Necking, (b) Cavity Formation,  
(c) Cavity coalescence to form a crack,  
(d) Crack propagation, (e) Fracture

### Ductile fracture



### Brittle fracture



# Fatigue



## Fatigue Characteristics

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- ❖ Fatigue: Behavior & failure of material observed under fluctuating/ cyclic loads.
- ❖ Fatigue occurs at stresses that are considerably smaller than yield/ tensile stress of the material.
- ❖ These failures are dangerous because they occur without any warning. Typical machine components subjected to fatigue are automobile crank-shaft, bridges, aircraft landing gear, etc.
- ❖ Fatigue failures occur in both metallic and non-metallic materials, and are responsible for a large number/ fraction of identifiable service failures of metals.

# Fatigue (Cont'd)



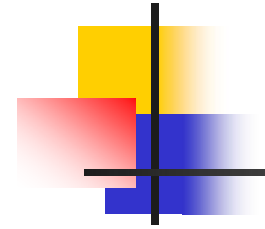
## Fatigue Identification 1

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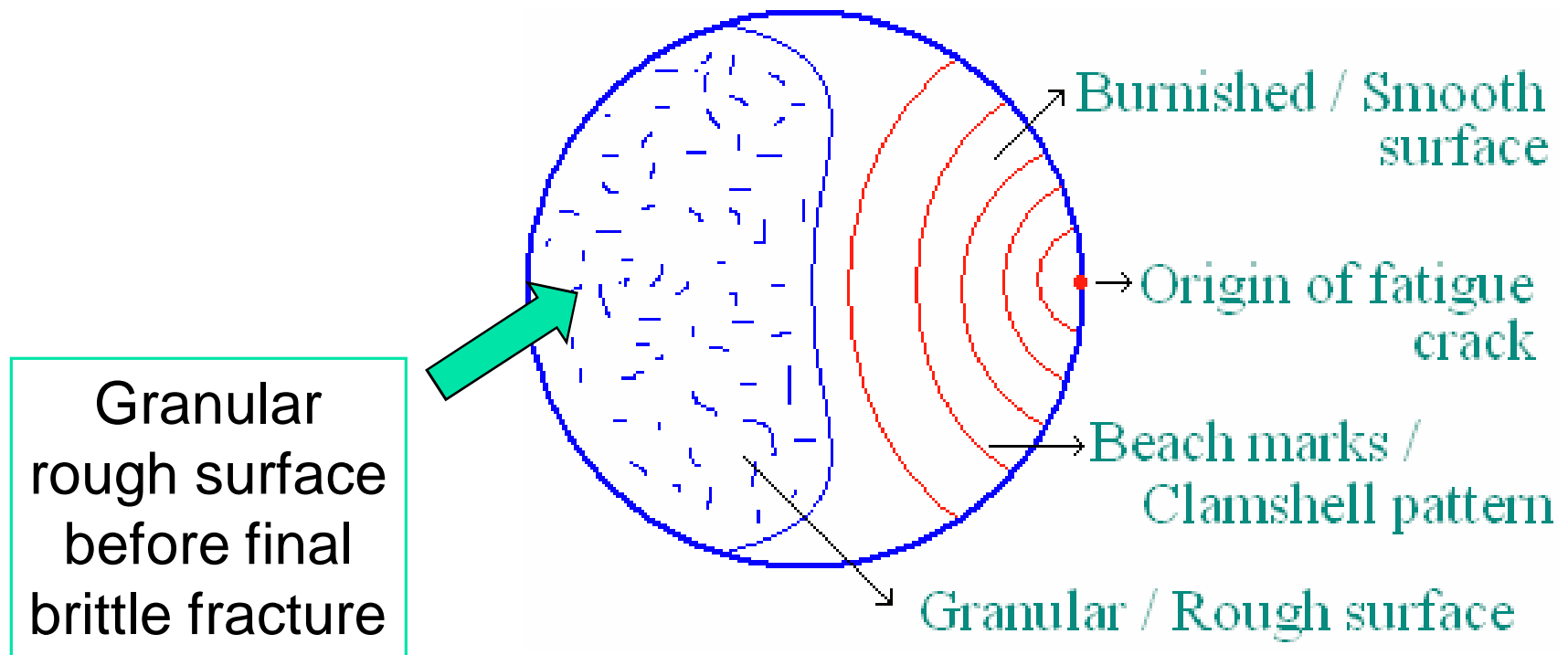
- ❖ Fatigue fracture surface is perpendicular to the direction of an applied stress.
- ❖ Any point with stress concentration such as sharp corner or notch or *metallurgical inclusion* can act as point of initiation of fatigue crack

# Fatigue (Cont'd)

## Fatigue Identification 2



Fatigue failure can be recognized from the appearance of the fracture surface





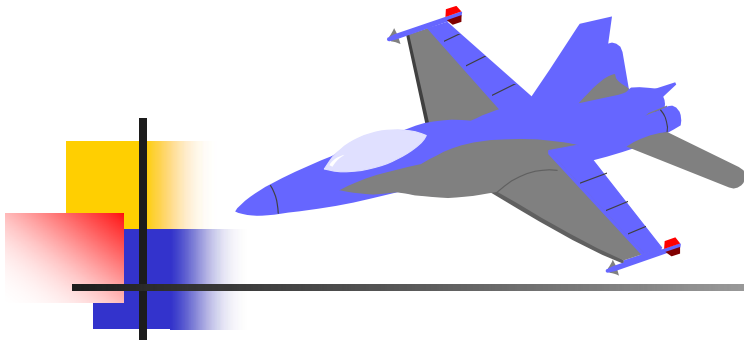
# Fatigue (Cont'd)



## Fatigue Conditions/ Requisites

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- ❖ Three basic requisites for occurrence of fatigue failure are:
  - ❖ (a) a maximum tensile stress of sufficiently high value
  - ❖ (b) a large enough variation or fluctuation in the applied stress, and
  - ❖ (c) a sufficiently large number of cycles of applied stress.



# Simulation

## What is Simulation?

- *Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behavior of the system and/or evaluating various strategies/methodologies for the operation of the system.*

# *Simulation* (Cont'd)



## *Simulation allows us to:*

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- ❖ Model complex systems in a detailed way.
- ❖ Describe the behavior of systems.
- ❖ Construct theories or hypotheses that account for the observed behavior.
- ❖ Use the model to predict future behavior, that is, the effects that will be produced by changes in the system.
- ❖ Analyze, test and evaluate the proposed methods/ hypothesis/ systems.

# *Simulation* (Cont'd)

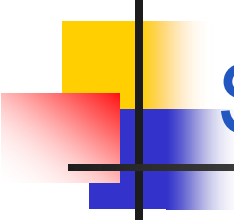


## Why use simulation?

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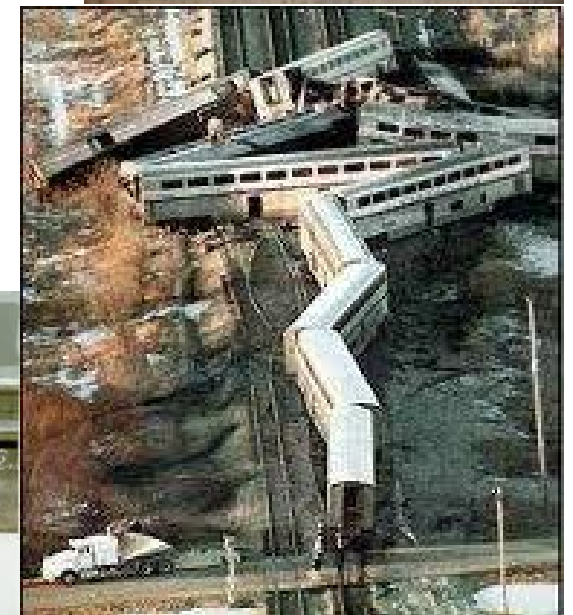
- ❖ Test without building
  - ❖ Experimental system.
  - ❖ New concepts.
- ❖ Test without disturbing
  - ❖ Costly experimentation.
  - ❖ Unsafe experimentation.
- ❖ Test without destroying
  - ❖ Determine limits of stress.
  - ❖ Predict the residual life

# Simulation *(Cont'd)*



Simulation's greatest strength  
is its ability to answer  
“**what if**” questions ...

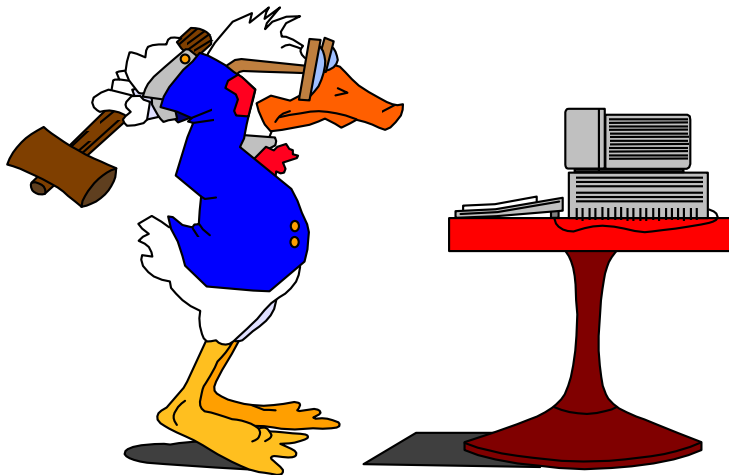
What if a part is operated with a  
**crack**?



# *Simulation* (Cont'd)

Is simulation flawless?

**NO,** Simulation has  
its own drawbacks...



# *Simulation* (Cont'd)

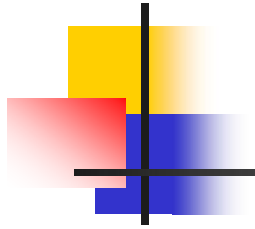


## Limitations of Simulation

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- ❖ Some simulations may take longer period of time to develop.
- ❖ Different simulations produce different results in repeated run.
- ❖ Do not generate optimal solutions.
- ❖ Users have to provide all constraints and frequent intervention.

# Objectives

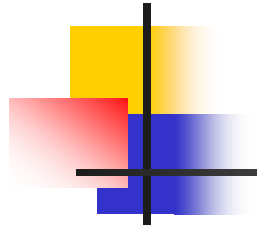


## Objectives of the research work:

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1. To study the stress distribution in components such as bars, beams and plates which may or may not have cracks using Element Free Galerkin Method (EFGM) and compare with theoretical solution.
2. To study the effect of various EFGM variable parameters on the solutions.
3. To analyze stable crack growth of cracked components with EFGM under mechanical loading.
4. To simulate and analysis of stress intensity factors, j-integral in the cracked components, remaining life prediction and their comparison with standard FEM packages such as ANSYS or NISA or suitable experimental techniques, if possible.

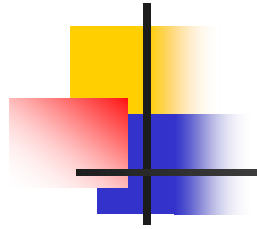




# Literature Review 1

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- ❖ The meshfree methods have been successfully applied in analysis and study of many fields with some limitations, such as:
  - ❖ Crack propagation
  - ❖ Large deformation
  - ❖ Fracture mechanics
  - ❖ Astronomy
  - ❖ Simulation of explosion

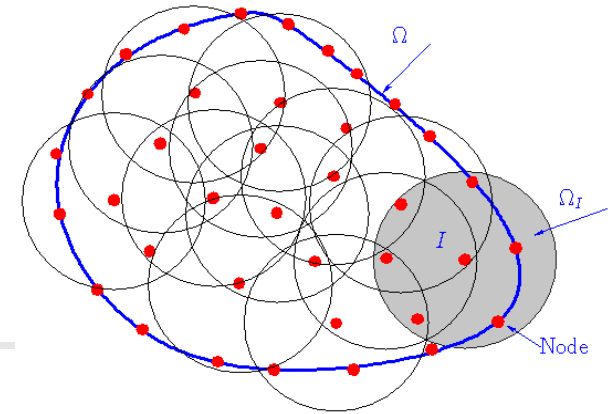
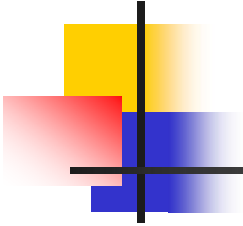


## Literature Review 2

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- ❖ Electrostatics
- ❖ Collision and accident Simulation
- ❖ Animation
- ❖ Bio-mechanics
- ❖ Manufacturing processes involving large deformation, forging, rolling

# Meshfree Methods

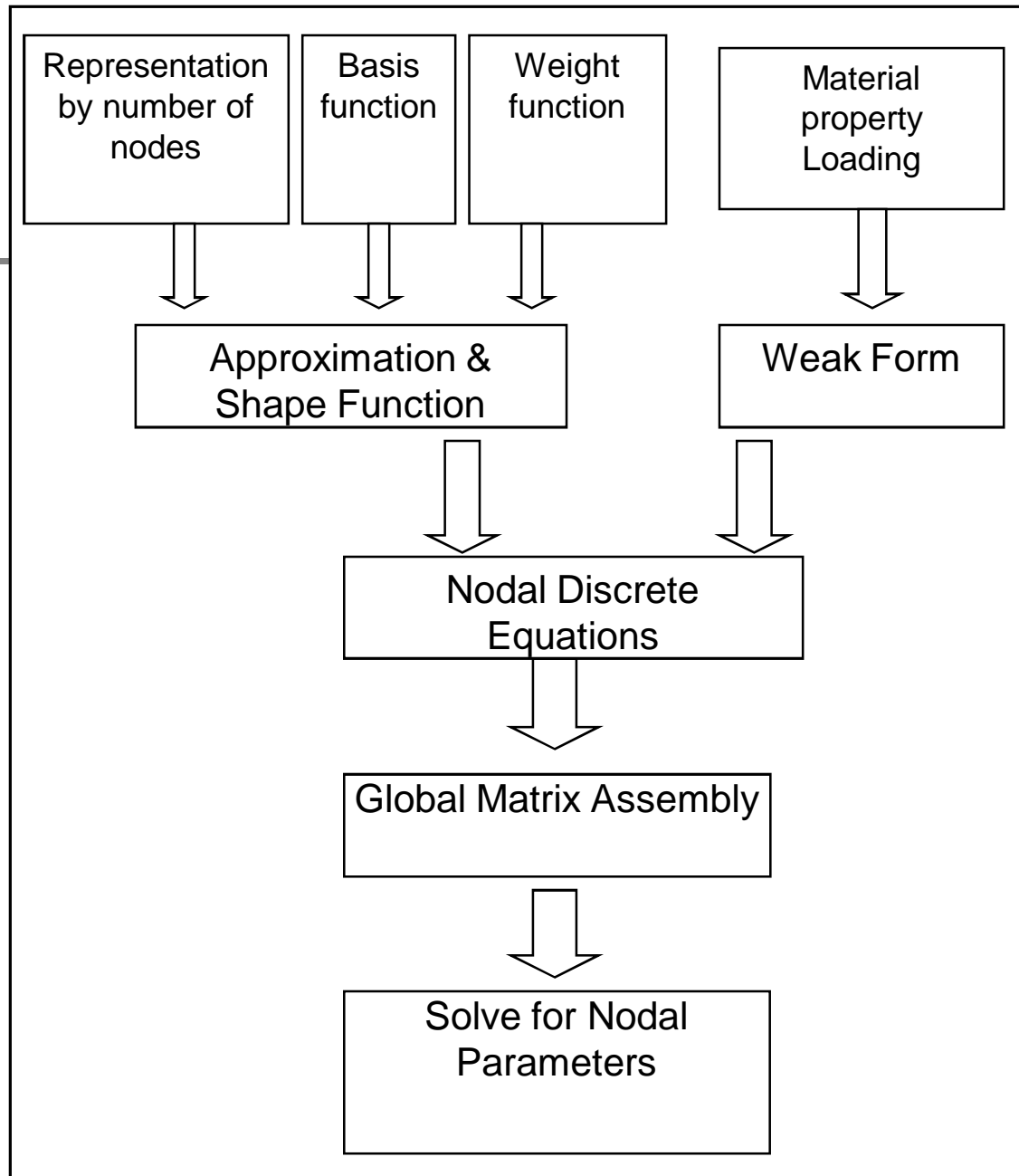


The objectives of the research work will be achieved by application of Meshfree methods as a simulation tool.

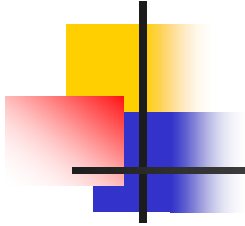
- ❖ Here onwards we shall have little introduction to meshfree methods:
- ❖ Steps involved in meshfree analysis?
- ❖ Why called meshfree?
- ❖ Discretization/ Representation of domain?
- ❖ Meshfree terminology?



## Steps INVOLVED



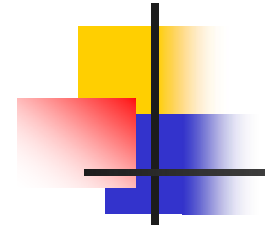
## Why called Meshfree Methods?



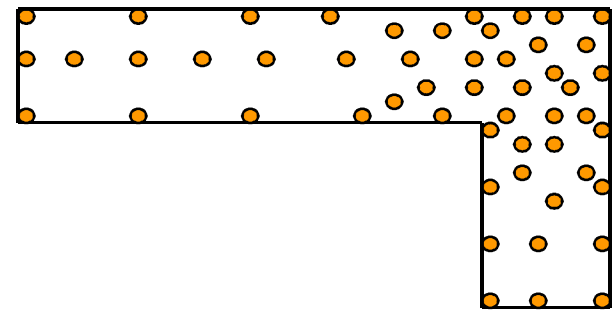
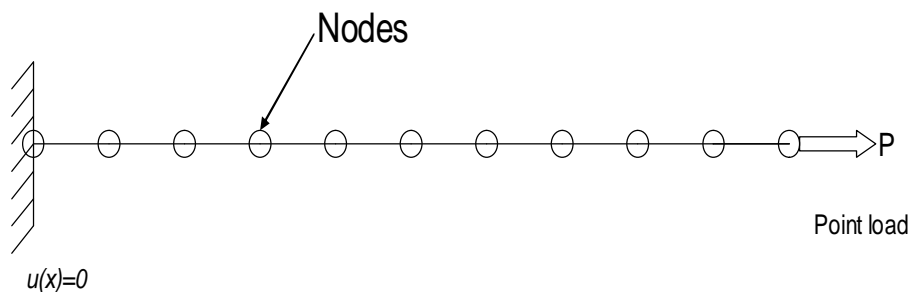
- ❖ A Mesh is defined as any of the open spaces or interstices between the strands of a net that is formed by connecting nodes in a predefined manner.
- ❖ Mesh free methods do not depend upon any elements for the connectivity, and hence these are called as:

“ Meshfree Methods ”

# Representation of domain?

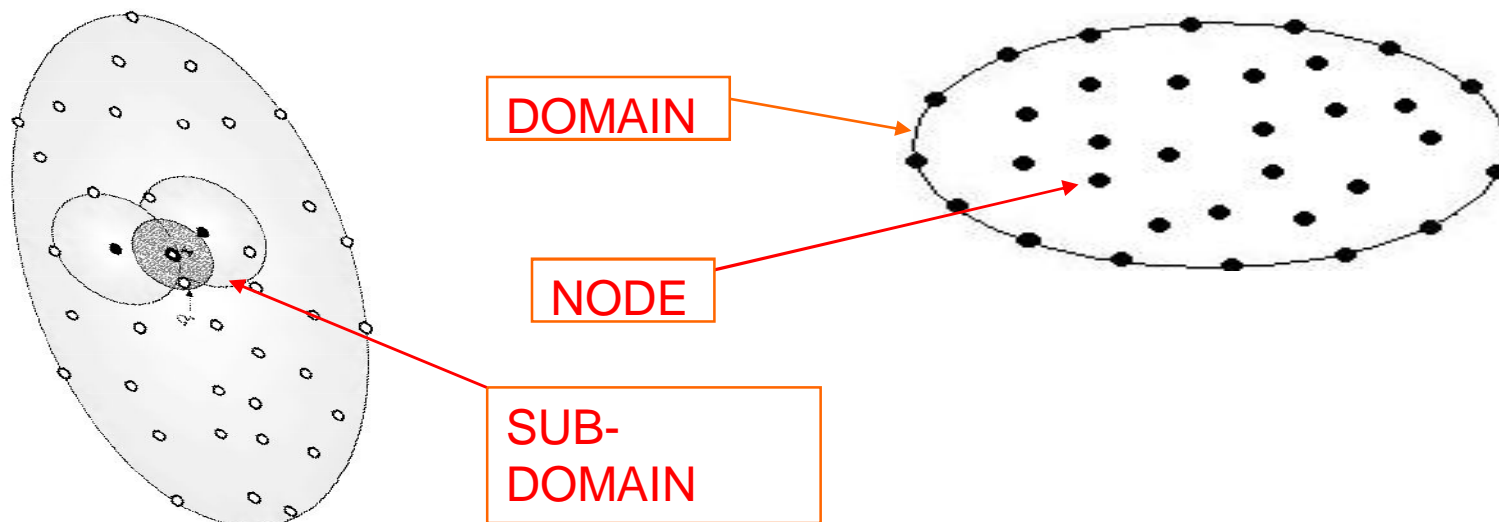


- ❖ The representation of the domain in the meshfree methods is done by only nodes distributed in the domain and on the boundary.
- ❖ The distribution of the nodes may or may not be uniform, this feature offers the selective distribution of nodes to evaluate the field variables of interest selectively in the complex domain e.g. corner of a bracket where the stress concentration is likely to be more.



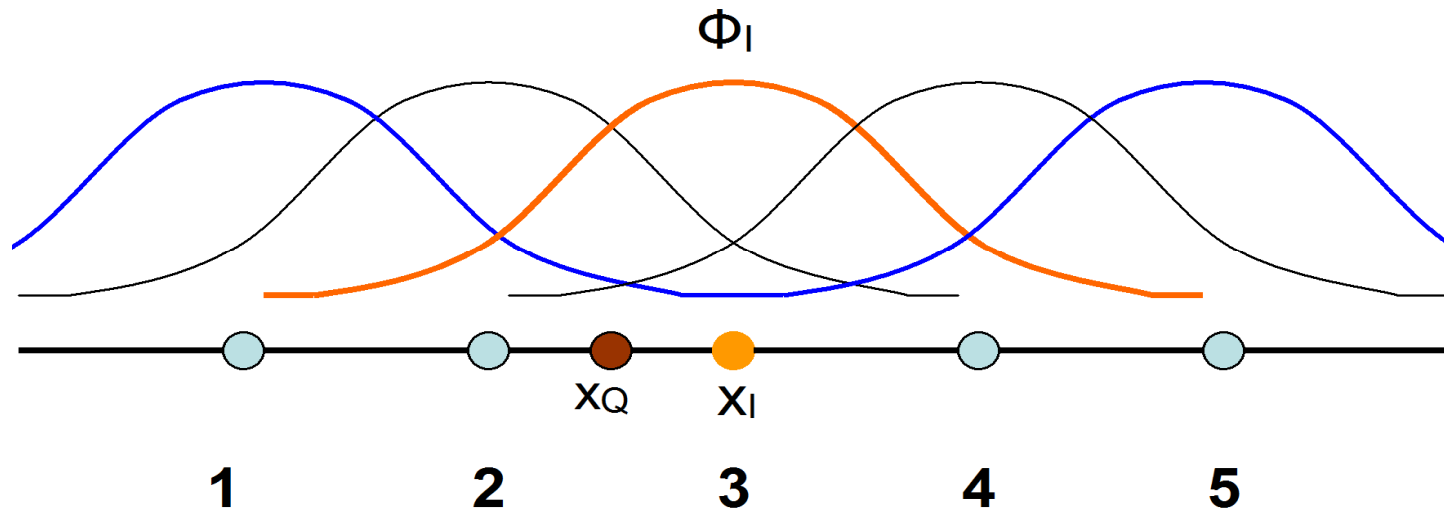
## ❖ *Support domain and influence domain*

- ❖ Support domain is defined as *the field / area or domain that a **point** exerts an influence upon, whereas,*
- ❖ Support influence is defined as *the field / area or domain that a **node** exerts an influence upon.*

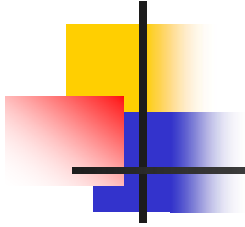


### ❖ Node connectivity

- ❖ The connectivity of the nodes in meshfree methods is established by the over lapping domains of influence.



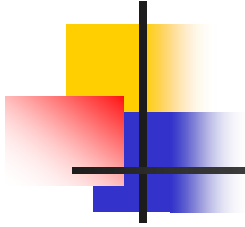




# Suggestions

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- ❖ Your questions, please!
- ❖ Your suggestions, please!



Thank you