SKMM 3033
Finite Element Method

Topic 1: Introduction to Finite Element Method

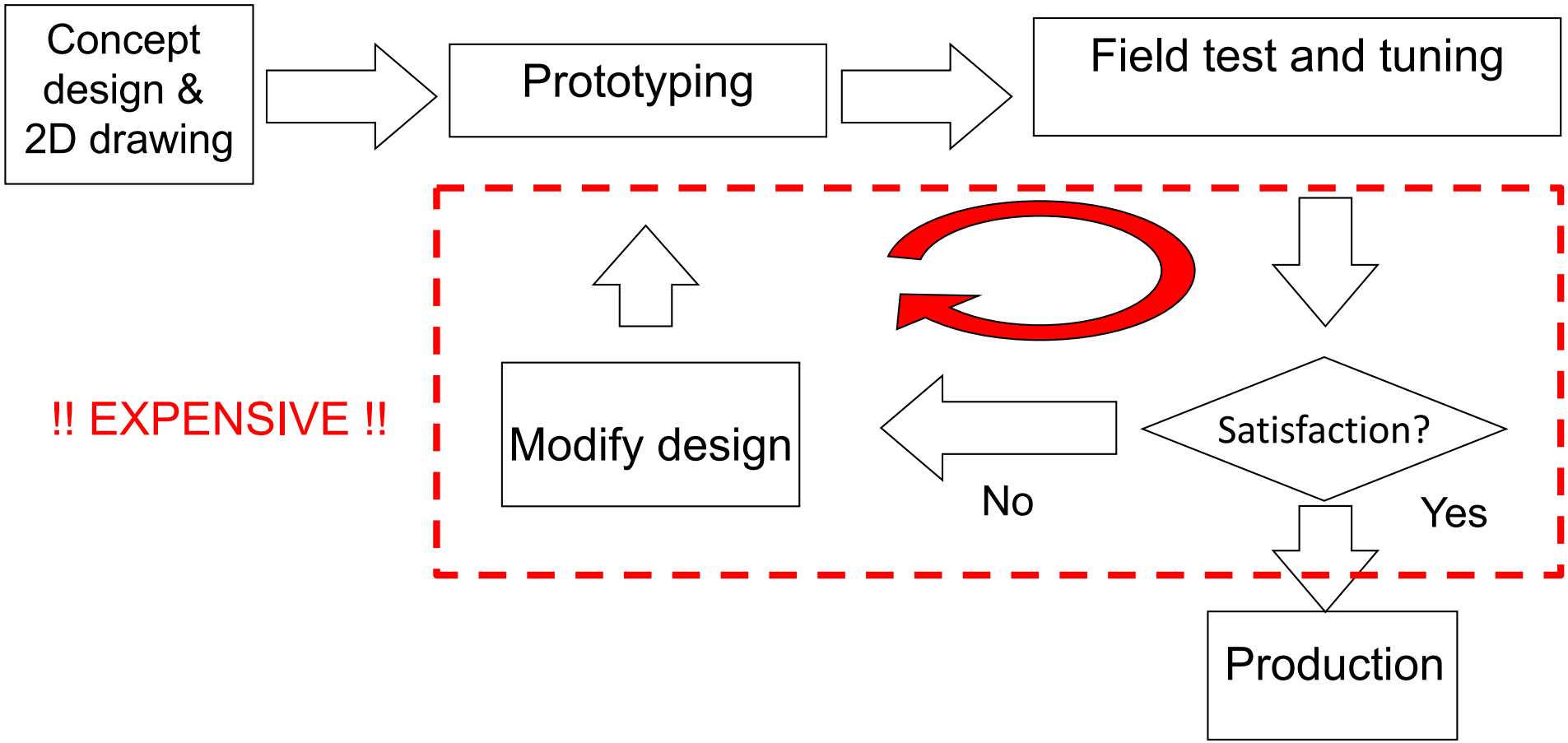
DR WILLIAM CHONG WOEI FONG
Department of Aeronautics, Automotive and Ocean Engineering
Faculty of Mechanical Engineering

By the end of the notes:

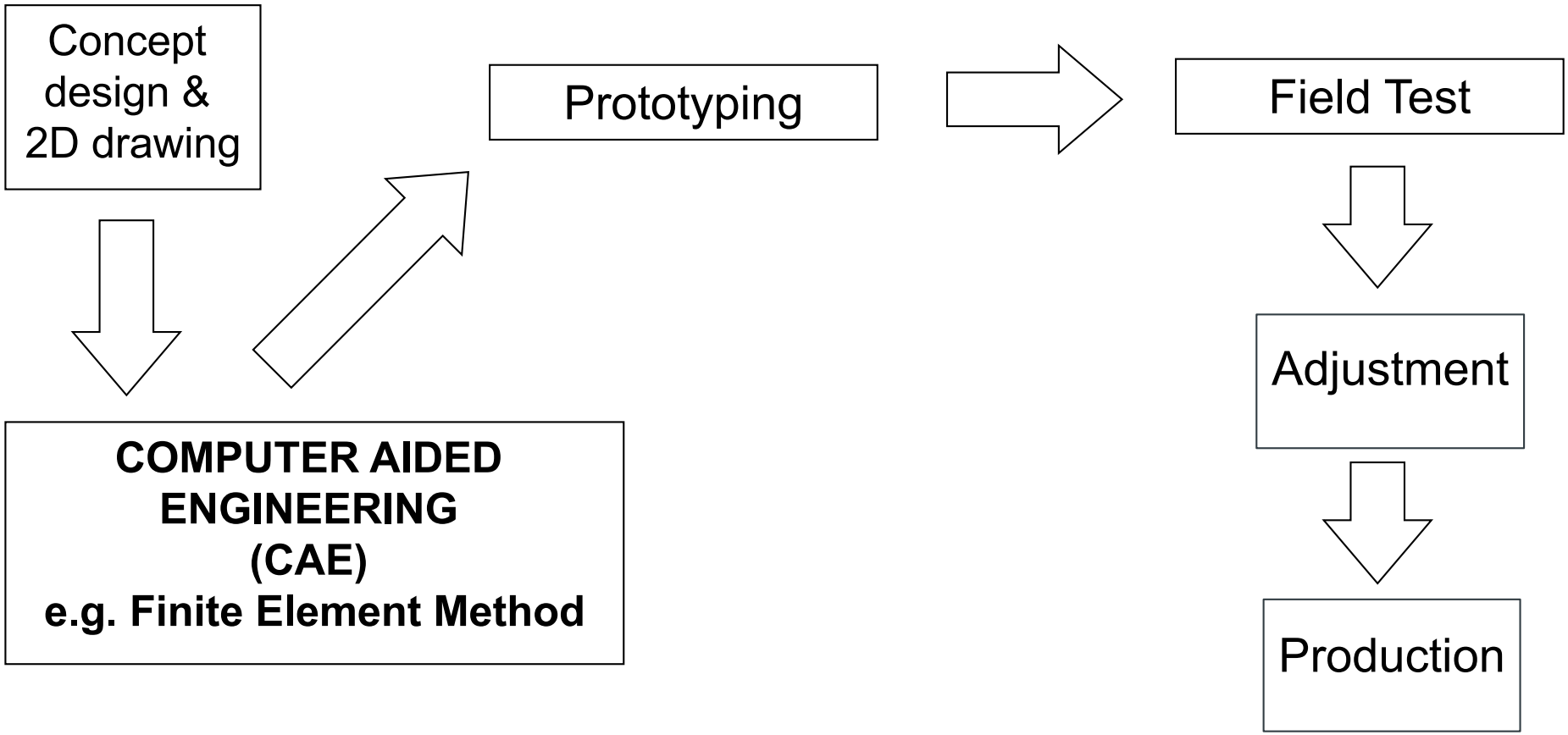
The students are expected:

- To explain the advantages and disadvantages of using FEM
- To understand the types of elements used in FEM

Traditional method of product development



Advanced method of product development



Advanced method of product development

Example:

Nissan Shatai Co. Ltd.

Takes 19 months to go from styling freeze to mass production

Through CAE via FEA,

- Reduced cycle to 12 months
- Reduced development cost by 50%
- Improved product quality

Advanced method of product development

To analyse engineering designs, can we use simple analytical approaches ??

Quite Impossible

However, using Finite Element Method

!!It is possible !!

Using Finite Element Method

We break a complex structure into simple structures we *can* analyse, and connect them with continuity

Finite Element Method

Break a complex structure into simple structures we *can* analyse, and connect them with continuity

+

Complexity makes computation essential

=

Finite Element Method (FEM)

Finite Element Method

A numerical method commonly used to solve complex engineering problems, involving complex geometries, combined loadings and advanced materials, where analytical solutions might too complex or not yet available

Some application areas of finite element method includes:

- Structural design – Static Stress Analysis, Dynamics, Crashworthiness
- Heat transfer – Steady-state, Transient
- Fluid Flow
- Soil Mechanics
- Acoustics

Finite Element Method

Advantages of finite element method include:

- Handles bodies with complex geometries
- Accepts simple to complex loading conditions
- Application of advanced material properties
- Considers various types of support conditions
- Variable element type and size
- Ease of model modification for design optimisation
- Nonlinear problems (geometric & material)

Finite Element Method

Disadvantages of finite element method include:

Just a model – "garbage in, garbage out"

Necessary steps before reliable predictions can be made:

Verification

- Confirms that the model is **numerically correct**
- But not that it represents reality

Validation

- Confirms that the model **represents reality**
- By comparison with laboratory/test data

Finite Element Method

Is this method accurate?

Yes, for simple problems and if material properties and loading condition are modeled very close to the actual conditions.

No, especially when the problems to be solved are too complex.

Among the sources of error involved in this method include:

- Geometrical simplification
- Interpolation function
- Material properties
- Round-off

Types of Elements

1-D elements

2-D elements

3-D elements

Types of Elements

1-D elements :

- Beam model of a bicycle frame
- Elements cross-sections are scaled according to cross-sectional properties
- Links between elements are crucial:

1. Trusses: pin/revolute joints tension/compression only
2. Beams: welded joints can transmit moments tension/compression OR bending

Types of Elements

2-D elements :

Plate-like geometry: sheet metal, composite structures, shells, pressure vessels

- A structural member that is small in one direction and large in the two other directions
- 2D elements also may be defined in 3D
- Dimensions of the structure should be ~10 or more times the thickness
- Plate elements are flat and Shell elements are curved
- Membrane elements are like shells, but stiff only in-plane (flexible in bending)
- Shell elements can be used for most problems

Types of Elements

3-D elements :

Complex geometry, solid structures, no dominant dimensions

- Bulk structures, irregular shapes, highly varying section thicknesses etc.
- Direct solution for deformations, stresses and strains in three dimensions

By the end of the notes:

You are expected to be able:

- To explain the advantages and disadvantages of using FEM
- To understand the types of elements used in FEM