SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore-35

Affiliated to The Dr.M.G.R Medical University, Chennai

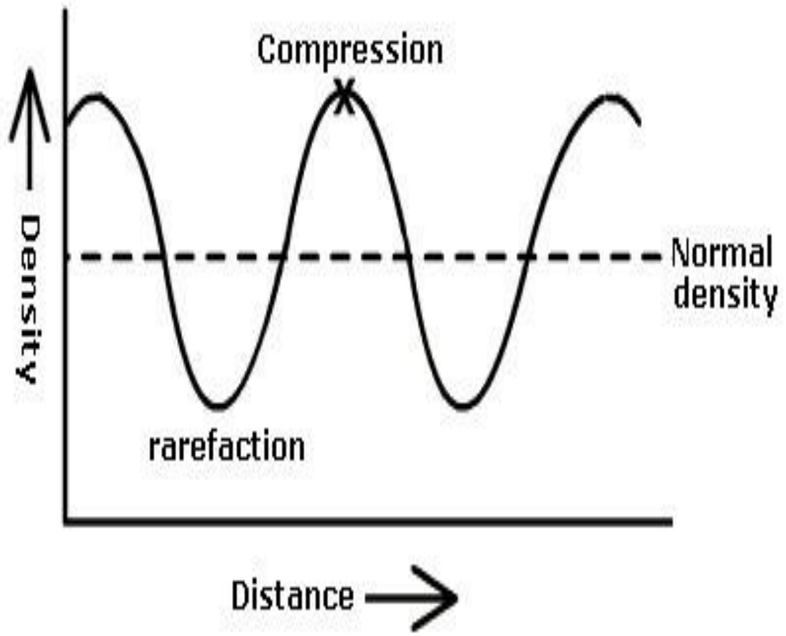
DEPARTMENT OF RADIOGRAPHY AND IMAGING TECHNOLOGY
III YEAR

COURSE NAME : EQUIPMENTS OF ADVANCED IMAGING MODALITIES

TOPIC : BASIC PRINCIPLES OF ULTRASOUND

INTRODUCTION

- Sound is a mechanical and longitudinal energy wave that travels in straight line.
- Requires medium for propagation.
- Sound waves travels by compressing and rarefacting matter.
- Ultrasound is a sound having frequencies greater than 20,000Hz or 20KHz which cannot be detected by human ear.
- Audible sound–15 Hz to 20,000 Hz.
- Diagnostic ultrasound frequency is from 1 to 30 MHz.



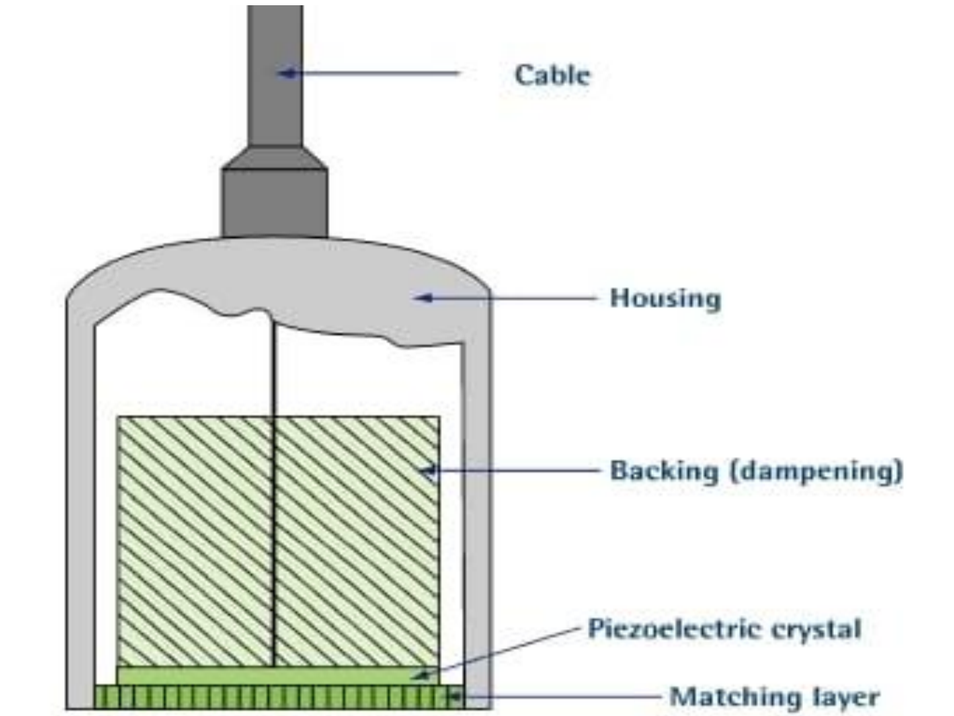
PRODUCTION OF ULTRASOUND

- Source – Transducer ,which works on the principle of piezoelectric effect.

- Transducer is a device that converts electrical energy into ultrasound energy and vice versa.

- Most important component is piezoelectric crystal which is made of quartz crystal or a synthetic ceramic such as Lead Zirconate Titanate(PZT).

COMPONENTS OF TRANSDUCER



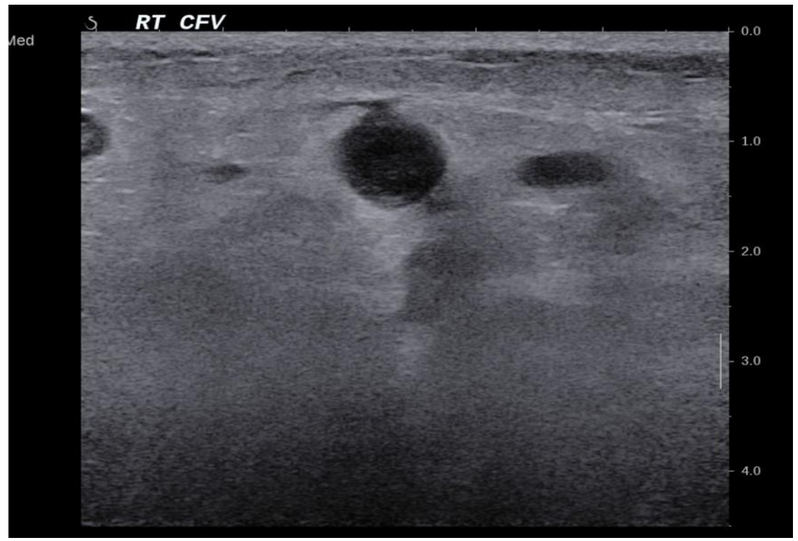
▲ Components of an ultrasound transducer.

TYPES OF TRANSDUCERS/PROBE

- Linear transducer
- Curvilinear transducer
- Phased array transducer
- Endocavitary transducer

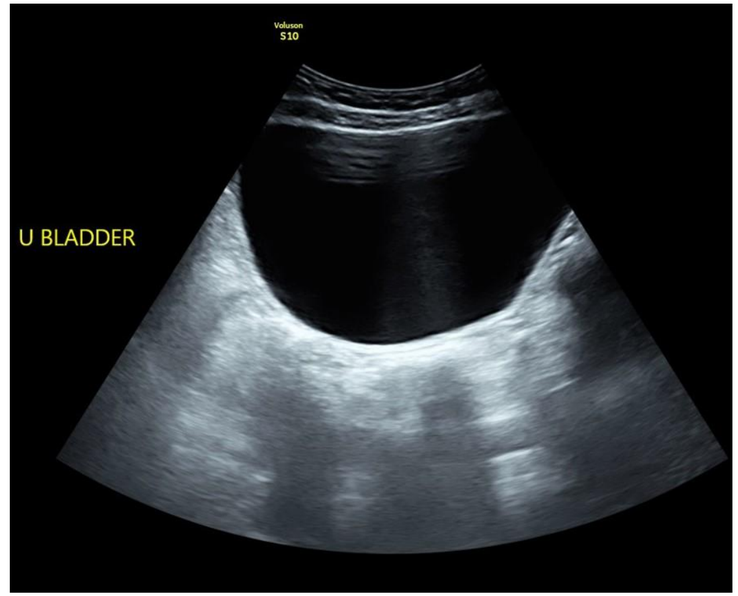
LINEAR TRANSDUCER

- Crystal arrangement – Linear
- High frequency (5 – 13 MHz
- Also called vascular probe
- FOV – Rectangular
- Footprint size – usually big
- Use – ultrasound imaging of superficial structures such as vascular accesses.



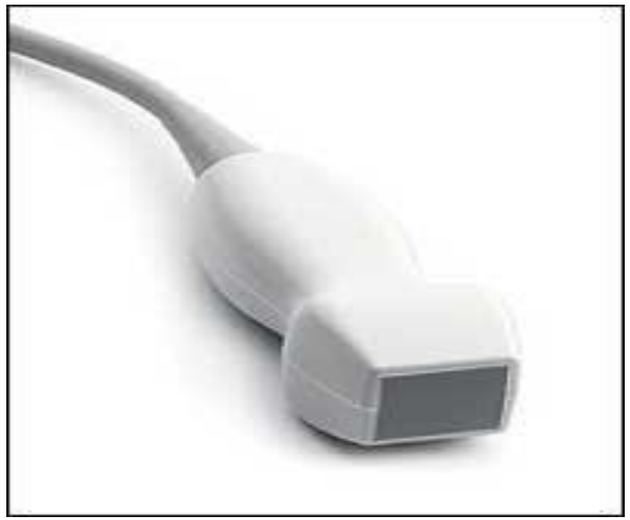
CURVILINEAR TRANSDUCER

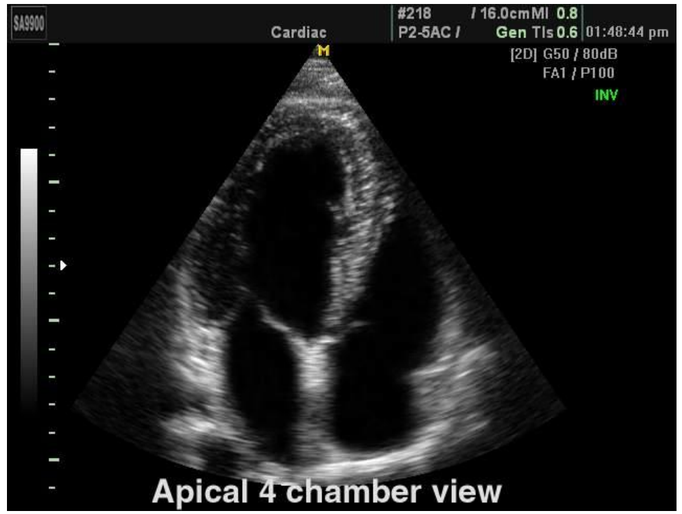
- Crystal arrangement - Curvilinear(along curved surface of the probe)
- Lower frequency (1 – 8 MHz)
- Also called convex probe
- FOV– Wider
- Footprint size – big
- Uses– scanning deeper structures (abdominal cases, pelvic imaging)



PHASED ARRAY TRANSDUCER

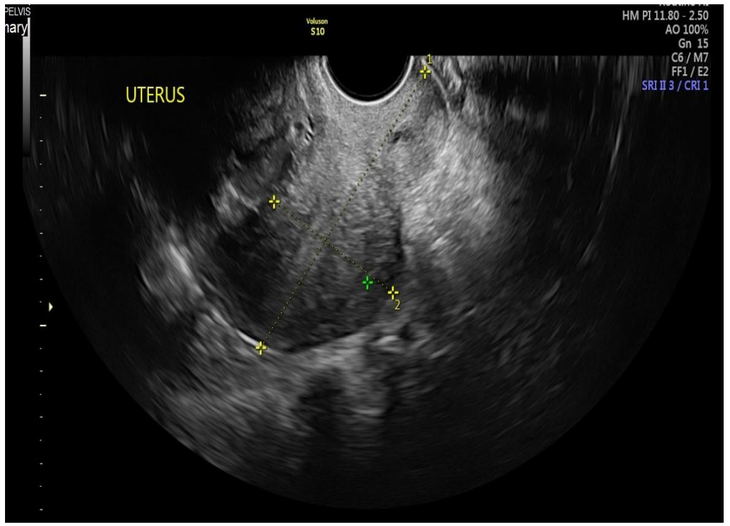
- Crystal arrangement – phased array
- Frequency : (2-8 MHz)
- FOV– almost triangular
- Footprint size – flat
- Uses – Cardiac imaging



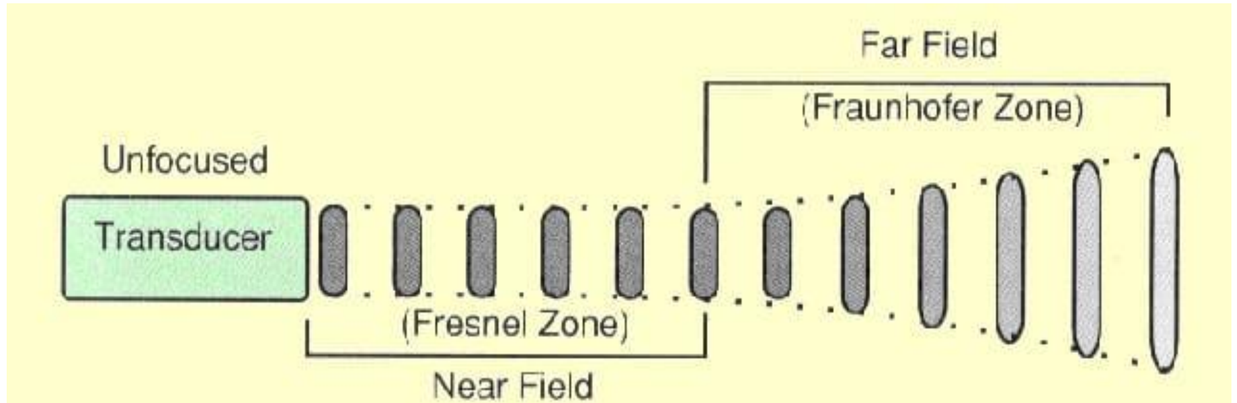


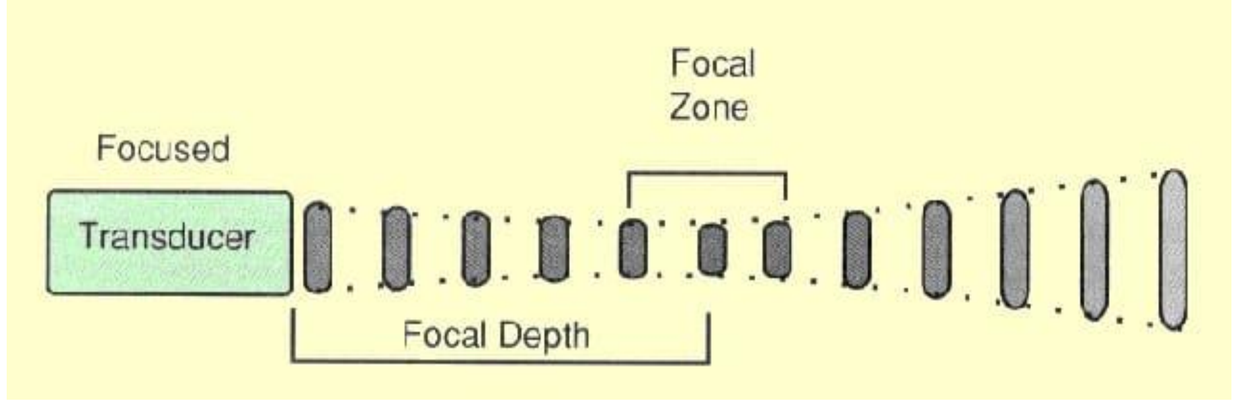
ENDOCAVITARY TRANSDUCER

- Crystal arrangement – Curved
- Higher frequency than curvilinear probes (8 – 13 MHz)
- FOV–Wider
- Footprint size – small
- Uses–TVS, mostly used in gynecological applications (early pregnancy), TRUS of prostate, prostatic cysts and seminal vesicle cyst.



CHARACTERISTICS OF ULTRASOUND





INTERACTION OF ULTRASOUND WITH MATTER

➢As incident ultrasound wave directed into the patient body,it traverses through different soft tissue interfaces, its intensity decreases.

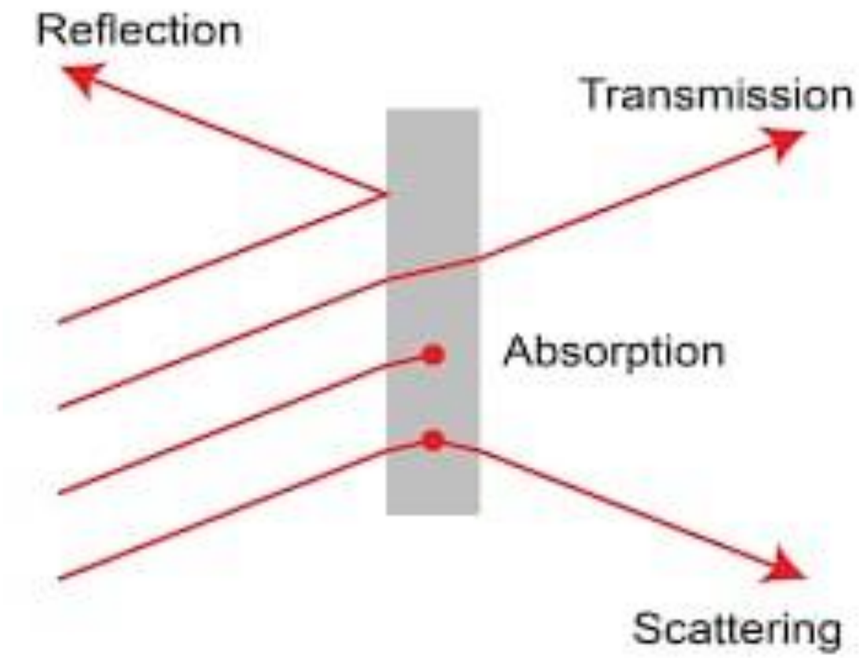
➢This decrease in intensity of incident ultrasound wave is known as attenuation.

➢Hence attenuation is the progessive weakening of ultrasound waves as it traverses through the medium.

Cont.,

➢The reduction in the intensity of ultrasound waves is caused by 5 factors:

-Absorption
-Reflection
-Scattering
-Refraction
-Depth



ABSORPTION

➢Absorption is the process where ultrasound energy is dissipated in the medium in the form of heat energy.

➢This is the only process where sound energy is converted into heat.

➢The absorption of ultrasound is related to frequency of transducer, viscocity of the medium and relaxation time of the medium.

➢Higher frequency– better resolution but more will be the absorption.

➢Thus to reach higher depth into tissue,lower frequency probe should be used so sound waves are less likely to be diverted.

REFLECTION

➢Reflection is the return of incident ultrasound energy as an echo directly back to the transducer when interaction with boundary.

➢The percentage of beam reflected at the interfaces depends on,

-Beam angle of incidence

-Tissue acoustic impedance

SCATTERING

- Redirection of sound in several directions is known as scattering.

- It occur because the tissues represent a bumpy or rough surface and their sizes are smaller than the wavelength of sound waves.

- It may cause loss of intensity of ultrasound waves.

REFRACTION

➢Refraction is the change in the direction of transmitted ultrasound energy.

➢It occurs when sound waves meets a tissue interface boundary at an angle other than 90 degree.

DEPTH

- Higher the depth more will be attenuation.

- Attenuation reduces the intensity of ultrasound waves due to reflection, refraction, scattering,frequency of transducer and absorption.

IMAGE DISPLAY

- Ultrasound images are created by using pulse echo principle.

- Transducer convert:
  - Electricity into sound – Pulse
  - Sound into electricity – Echo

- The depth of a relative structures is described from the delay between pulse transmission and echo reception.

IMAGING MODES

- A mode – Amplitude mode
- B mode – Brightness mode
- M mode – Motion mode

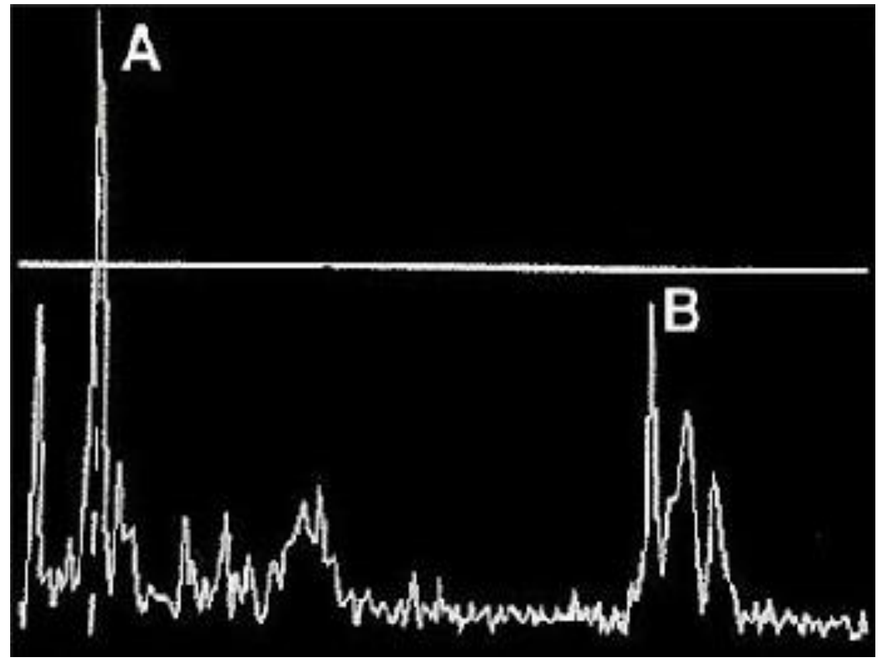
AMPLITUDE MODE

➢In A-mode,echoes are displayed as spikes projecting from a baseline as amplitude versus depth.

➢Spike height is proportional to echo intensity,with strong echoes producing large spikes.

➢It helps to distinguish interfaces along beam path and provides depth information.

➢A mode is used in ophthalmology and echocardiography.



BRIGHTNESS MODE

- The B mode made the ultrasound as a diagnostic tool, especially in abdominal diseases.
- It provides a picture of a slice of tissue.
- In B mode,a two dimensional(2D) slice of anatomy of the patient is imaged.

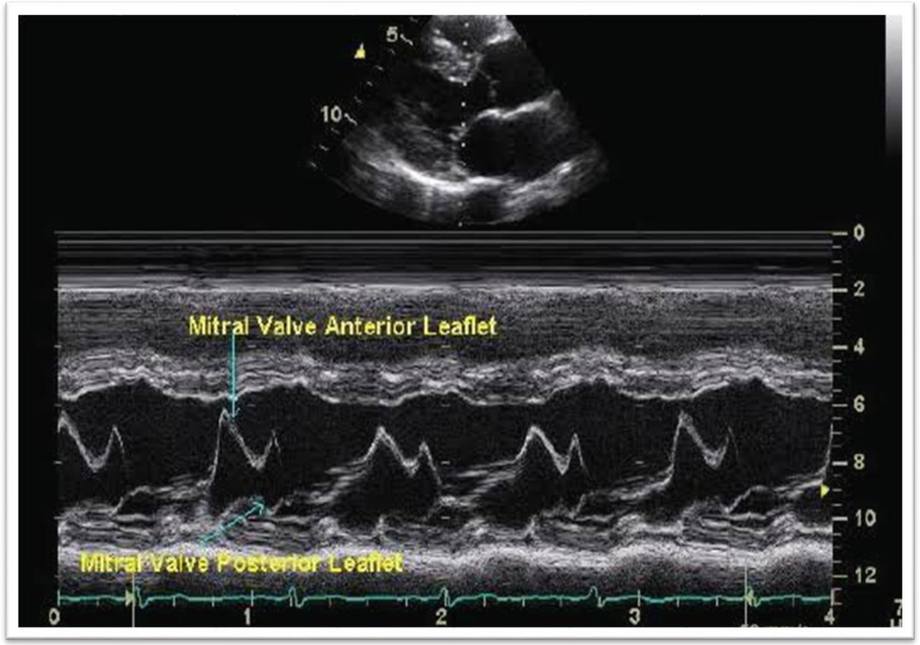
MOTION MODE

➢In M mode, the variation of signal amplitude is converted into series of dots.

➢The brightness of dot is proportional to the amplitude.

➢It is recorded over a period of time and helps to see the change in position of an interface.

➢It is used to evaluate cardiac value motion and cardiac anatomy. However, it has limited role in imaging, due to arrival of doppler ultrasound.



ADVANTAGE & DISADVANTAGE

ADVANTAGE :

- Non – invasive and no radiation, hence allowing pregnant women to use this imaging technique.
- Used to detect blood flow through vessels.

DISADVANTAGE :

- Air will interfere with echoes

REFERENCE

- Basic Radiological physics (2nd edition) by Kuppusamy Thayalan.