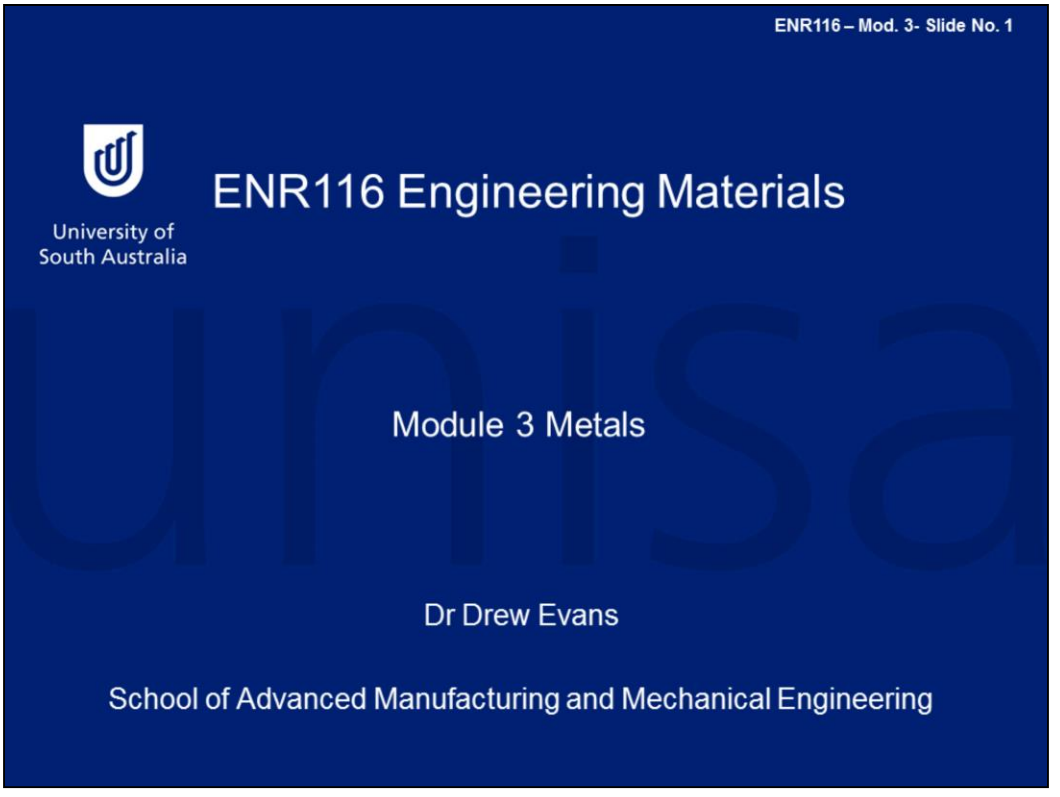

- My name is Drew Evans, and welcome to Module 3 – Metals

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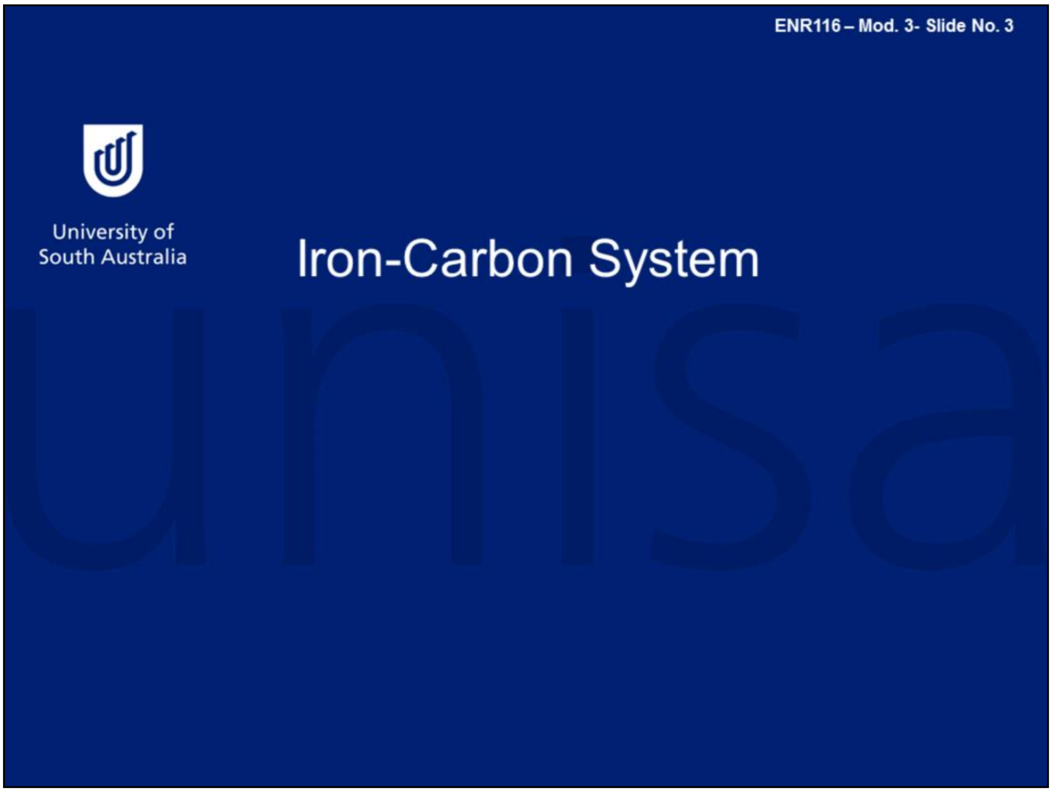

• This presentation will cover an Introduction to the Iron-Carbon System

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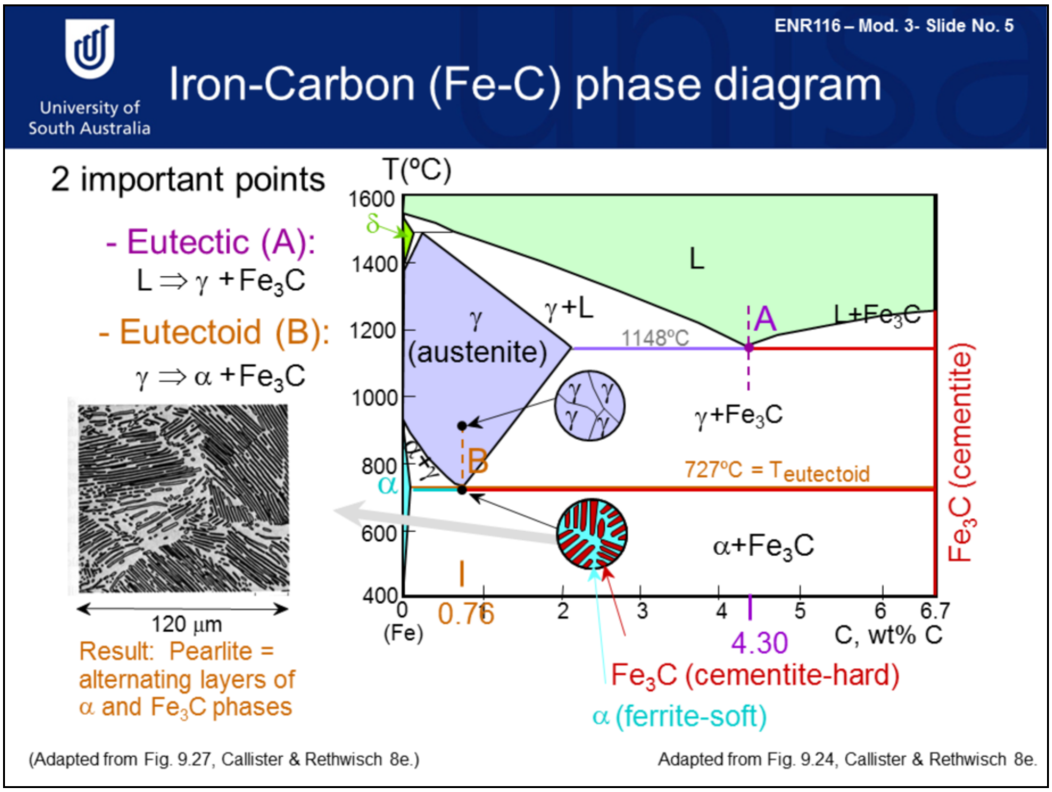
Intended Learning Outcomes

At the end of this section, students will be able to:-

- Understand what a phase transformation is.
- Identify the important phase transformations in the Fe-C system.
- Recognise how both composition and processing influence phase transformation.

By the end of this presentation, you should be able to,

- Understand what a Phase Transformation is
- Identify the important Phase Transformations in the Fe-C system
- Recognise how both the Composition and Processing of the Fe-C alloy influences the Phase Transformation



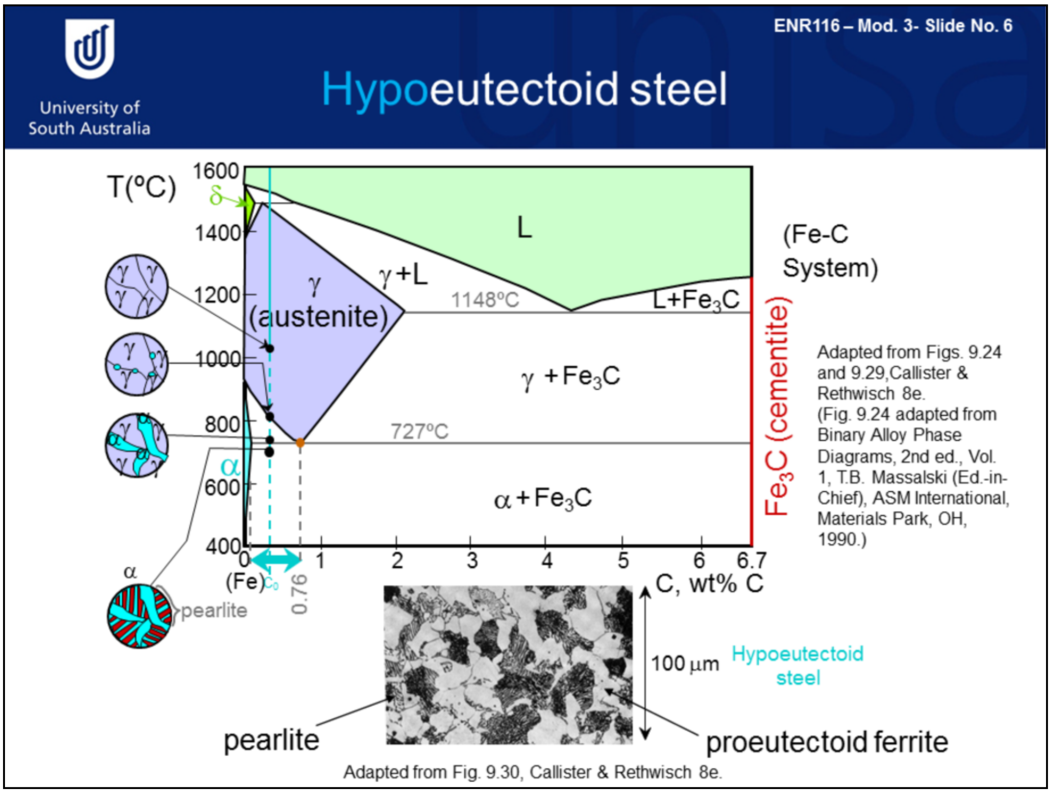
A binary system of considerable importance is the Fe-C system.

This system is important because it forms the basis of steels and cast irons; the structural materials that underpin much of modern society

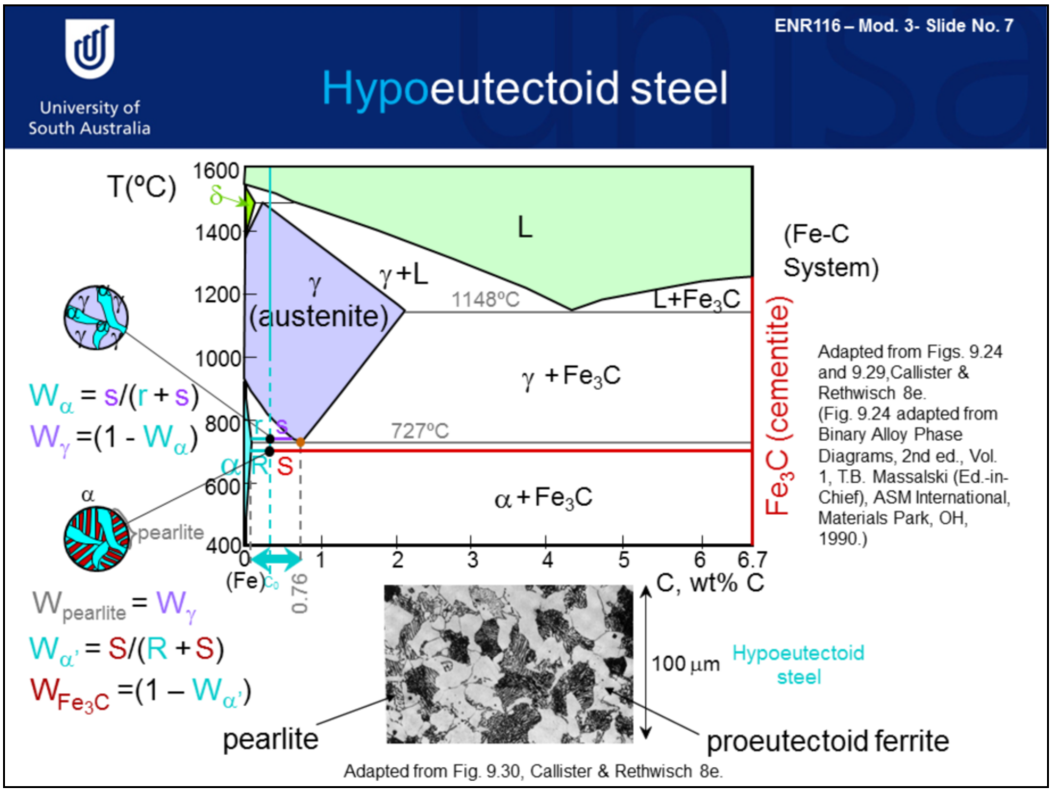
Steel is an Fe-C alloy containing between 0.008 and 2.14 wt% C, while cast iron contains between 2.14 and 6.70 wt% C

When looking at the Fe-C Phase Diagram, two points of interest are observed. Like the Binary Eutectic Phase Diagram, a Eutectic Point is observed which occurs at 1148°C and 4.30 wt%. Remembering that at the Eutectic Composition ,the minimum melting Temperature of the system occurs

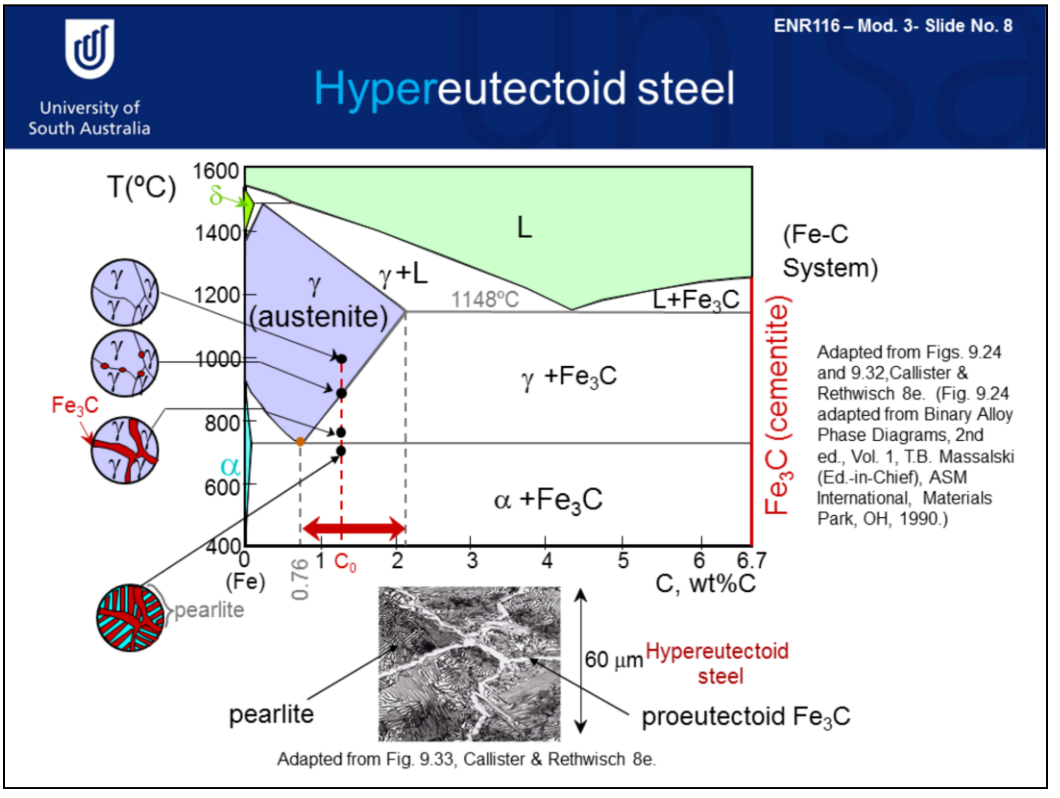
- The second point of interest in the Fe-C Phase Diagram is at 727°C and 0.76 wt% C. This point is referred to as the Eutectoid Point, which is Eutectic-like, but rather than a liquid transforming, a solid transforms into two solid Phases upon cooling
- In a similar manner to the Eutectic Reaction, the limited solubility of one element in the other leads to this transformation
- At the Eutectoid Composition, the material is referred to as the Eutectoid Alloy
- For the Fe-C system at the Eutectoid Point, austenite cools to directly form a mixture of ferrite and cementite
- In the Phase Diagram the austenite is labeled as γ, ferrite as α and cementite as Fe_3C
- The mixture of ferrite and cementite, which is observed as a lamellar structure, is commonly known as Pearlite
- The lamellar structure grows via a diffusion process of C away from the ferrite regions to the cementite regions
- Pearlite takes its name from the mother-of-pearl appearance when the structure is viewed under low magnification using a microscope



- Lets now consider Compositions of the Fe-C system below the Eutectoid Composition
- These are referred to as Hypoeutectoid Steels when using the Fe-C system, or Hypoeutectoid alloys in the more general case
- When cooling from the austenite Phase to room temperature, the material will pass through the ferrite plus austenite ($\alpha + \gamma$) Phase before the Pearlite Phase Field
- Initially, the austenite begins to transform to ferrite at the grain boundaries
- These then grow in size as more austenite transforms to ferrite
- Below the Eutectoid Temperature the remaining austenite transforms to Pearlite
- The resulting structure has grains of pearlite and proeutectoid ferrite, which is the ferrite formed above the Eutectoid Temperature



- By using two separate tie-lines, one above and one below the Eutectoid Temperature, it is possible to determine the phase fraction of proeutectoid ferrite and pearlite, and the phase fraction of total ferrite and cementite
- Above the Eutectoid Temperature, the Lever Rule applied to the tie-line gives the phase fraction of austenite and proeutectoid ferrite
- It is this phase fraction of austenite that will later transform to pearlite when cooled into the α + Fe_3C Phase Field
- Below the Eutectoid Temperature, the Lever Rule applied to the tie-line gives the phase fraction of eutectoid ferrite to cementite within the pearlite grains only
- Using the phase fraction information above and below the Eutectoid Temperature it is then possible to determine the total phase fraction of ferrite and cementite



• Now what microstructure might be observed for Hypereutectoid steel? i.e. at Compositions above the Eutectoid Composition

• When cooling from the austenite Phase to room temperature, the material will pass through the austenite plus cementite (? + Fe3C) Phase before the Pearlite Phase Field

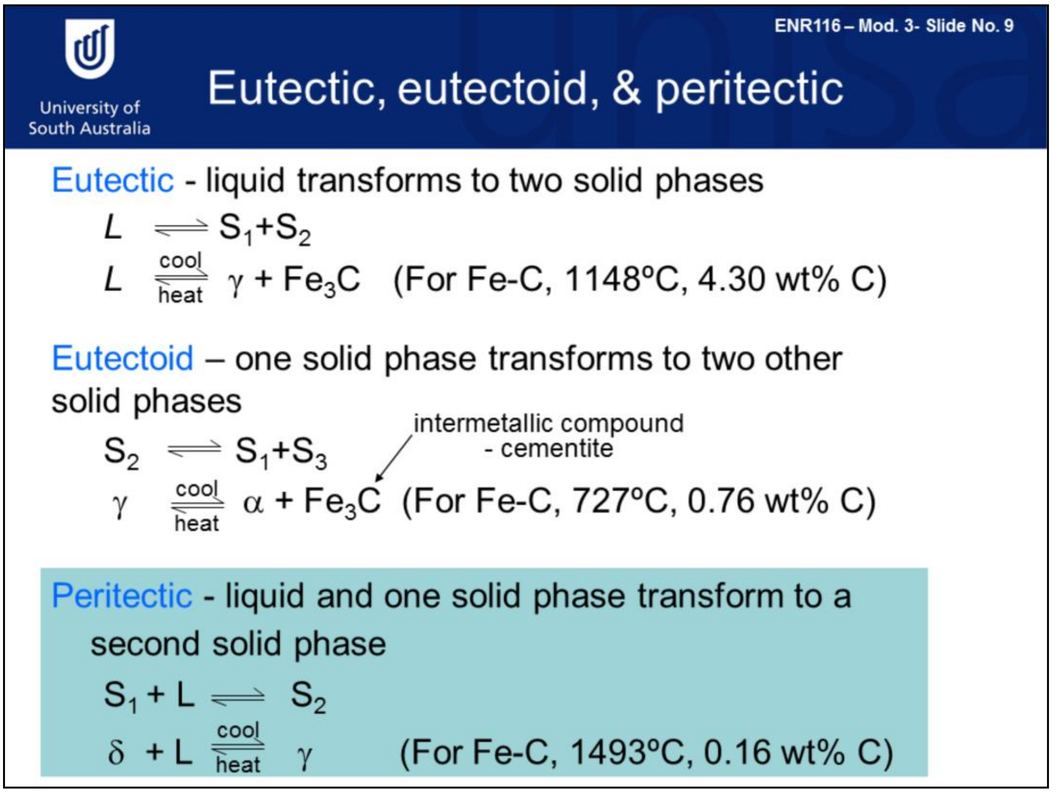
• In a similar manner to the Hypoeutectoid steel, the austenite begins to transform at the grain boundaries, but in the case of Hypereutectoid steel the transformation is to cementite

• When transitioning through the ? + Fe3C Phase Field, the phase fraction of cementite increases

• Transitioning through the Eutectoid Temperature then sees the remaining austenite transform to the pearlite structure

• The final resulting microstructure has both pearlite and proeutectoid cementite

• Just like with the Hypoeutectoid steel, it is possible to use tie-lines and the Lever Rule to determine the phase fraction of pearlite and proeutectoid cementite, as well as the phase fraction of total combined cementite and ferrite



- From studying the Fe-C system, several points of interest have been observed
- Firstly, the Eutectic reaction occurs at the Eutectic Point where a single liquid phase transforms into two solid phases
    - At 1148°C and 4.30 wt% C the liquid transforms to austenite and cementite
- Secondly, the Eutectoid reaction occurs at the Eutectoid Point where a single solid phase transforms into two solid phases
    - At 727°C and 0.76 wt% C the austenite transforms to ferrite and cementite
- A third point of interest is the Peritectic Point, which is similar to the Eutectic and Eutectoid Points
    - At this point a reaction occurs where a liquid and one solid transforms to a second solid phase
    - In the Fe-C system, this can be observed at 1493°C and 0.16 wt% C, where δ-ferrite and liquid transform to austenite
- All these points of interest relate to reactions that transform one phase to two other phases or vice versa, where the terms Eutectic, Eutectoid and Peritectic refer to whether the phases transforming or being transformed are solid and/or liquid

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Summary

- Important phase diagram phase transformations include eutectic, eutectoid, and peritectic.
- The Fe-C system is very versatile – this allows many microstructures and mechanical properties to be designed.

•In summary,

- On a Phase Diagram, there are several points of interest at which reactions occur from which microstructural change is observed
  - These include the Eutectic, Eutectoid and Peritectic points
- The Fe-C system is versatile, with changes in the Composition (i.e. wt% C) leading to a range of different microstructures to be created
  - These different microstructures have different mechanical properties, and hence the Fe-C system allows for a variety of materials to be made from the same starting materials for a range of different applications

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Thank you

• If you have any questions or desire further clarification please post a question or comment on the ENR116 Discussion Forum