** IMPORTANT **

Please read the document “POE Exam Directions – Fall 2006” before you administer and grade your students’ exams.

All three parts of the POE End-Of-Course exam (A, B & C) require a conversion to obtain a student’s score out of 50 points.

Each student’s raw (unconverted) scores for Parts A & B or Parts A & C must be entered into the Excel score conversion chart (POE Conversion Chart – Fall 2006.xls) in order to obtain the student’s calculated score.

The spreadsheet is designed to convert the student’s raw score for each part of the exam, and to calculate the student’s final test score for either the high school or college credit portion of the exam.

A sample conversion chart for each part of the exam has been included below. These are for information purposes only. Please download and use the spreadsheet to obtain your students’ final exam scores and do not convert and add your students’ scores by hand.

### Part A Scoring Conversion Chart

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**Answer Breakdown: A-10; B-10; C-10; D-10**
1. Study the strut and cable in Figure 1 and its free body diagram in Figure 2, and answer the following questions.

a) Calculate the length of truss member BC. (answer precision = 0.00) [3 points]
\[
\cos \theta = \frac{AB}{BC}
\]
\[
\cos 50^\circ = \frac{10 \text{ ft}}{BC}
\]
\[
BC = \frac{10 \text{ ft}}{.643} = 15.56 \text{ ft}
\]
1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units

b) Using the free body diagram in figure 3, calculate the magnitude of the reaction force \(F_{BC}\) which occurs at joint B. (answer precision = 0.00) [3 points]
\[
F_{BC} \sin \theta - 140 \text{ lbs.} = 0
\]
\[
F_{BC} \times .766. = 140 \text{ lbs}
\]
\[
\frac{140 \text{ lbs}}{.766} = F_{BC}
\]
\[
F_{BC} = 182.76 \text{ lbs.}
\]
1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units
2. A soccer ball is kicked from the ground with a velocity of 60 ft/s at an angle of 40° degrees, and eventually lands at the same height, as shown in Figure 4. Use 32.15 ft/sec² for acceleration due to gravity.

How far away does the ball land from the place it was kicked? (answer precision = 0.00) [3 Points]

$$X = \frac{v_i^2 \sin 2\theta}{g}$$

$$X = \frac{(60 \text{ ft/sec})^2 \sin(2 \times 40^\circ)}{32.15 \text{ ft/sec}^2}$$

$$X = 110.30 \text{ ft}$$

1 point for stating the formula

1 point for showing substitutions

1 point for the correct answer with correct units

3. The cylindrical bar, shown in Figure 5, has a cross-sectional area of 7 in² and is subjected to an axial load; as it is being pulled away from a wall with a force of 200 lbs. Determine the stress in the bar. (answer precision = 0.00) [3 Points]

$$\sigma = \frac{P}{A}$$

$$\sigma = \frac{200 \text{ lbs}}{7 \text{ in}^2}$$

$$\sigma = 28.57 \text{ psi}$$

1 point for stating the formula

1 point for showing substitutions

1 point for the correct answer with correct units
4. A tensile test specimen was tested under a tensile load. The force – displacement diagram that resulted is shown in Figure 6.

   a) Study Figure 6 below. Write the letter from the diagram that matches each term. [4 Points]

   D       Rupture
   B       Yield Point
   A       Proportional Limit
   C       Ultimate Force

   b) What kind of material would the specimen be if it had failed at point B? Circle the correct answer below. [1 Point]

   Brittle material
   Ductile material
5. The closed-loop program shown below is designed to send a shuttle back and forth between two points. In one direction the lamp will be on, and in the other direction the lamp will be off. Study the program description and decide which of the program elements from the answer bank (A through G) must be used to complete the flowchart program. Write the letter of the correct icon in the proper empty box. No icon will be used more than once, and some may not be used at all. [4 points]

Program Description:
When the program starts, shuttle (M1) is turned ON in the clockwise direction, and the computer checks to see if limit switch I1 (wired normally open) is being pressed. The program will loop back until switch I1 is pressed. From there, shuttle M1 will stop and then start again in the counter-clockwise direction while turning on lamp M2. The computer will then loop back until switch I2 (wired normally open) is pressed. Once I2 has been pressed, lamp M2 turns off and shuttle M1 stops. The program then loops back to the beginning.

Answer Bank
A
B
C
D
E
F
G
6. The incomplete image below identifies a 9-step design process. You are to place the steps of the design process in the right order below. Five answers have been completed. [4 points]

2. Define the Criteria
8. Test and Evaluate
1. Identify the Need, Want or Problem
4. Generate Alternative Solutions
3. Investigate and Research

7. Model and Prototype
5. Choose a Solution
9. Redesign and Improve
6. Develop the Solution

1 point for each correct answer
7. Study the technical drawing below, and sketch the missing object lines and hidden lines. There are two missing lines in each of the orthographic views. [6 points]

Each view is worth a maximum of 2 points. 1 point for each correct line.
8a. What class lever is shown in Figure 6? Justify your answer. [2 points]

**Figure 6 shows a first class lever. First class levers always have the fulcrum located between the effort and the load (resistance).**

1 point for stating the correct class of lever 1 point for stating a valid justification

8b. How much resistant force is needed to balance the 18 lb. load? (answer precision = 0.0) [3 points]

**Method 1**

\[ L_E \times E = L_R \times R \]

\[ 25 \times 18 = 4 \times R \]

\[ 450 = 4 \times R \]

\[ R = \frac{450}{4} \]

\[ R = 112.5 \text{ lbs.} \]

**Method 2**

\[ MA = \frac{L_E}{L_R} \]

\[ MA = \frac{25}{4} \]

\[ R = 6.25 \times 18 \]

\[ R = 112.5 \text{ lbs.} \]

**Method 3**

\[ \Sigma M = 0 = CCW - CW \]

\[ 0 = 25 \times 18 - 4 \times R \]

\[ 4 \times R = 450 \]

\[ R = \frac{450}{4} \]

\[ R = 112.5 \text{ lbs.} \]
1. Study the struts in Figure 1 and the incomplete free body diagram in Figure 2, and answer the following questions.

a) Calculate the length of truss member AB. (answer precision = 0) [3 points]

\[ a^2 + b^2 = c^2 \]
\[ 5 \text{ ft}^2 + 12 \text{ ft}^2 = c^2 \]
\[ 169 \text{ ft}^2 = c^2 \]
\[ c = \sqrt{169} \text{ ft} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units

b) If the horizontal reaction force at joint B is 4137.93 lbs. (acting to the left), what is the magnitude and type of force (tension or compression) that is being carried by member AB? (answer precision 0.0) [4 points]

\[ 0 = F_{AB} \cos 22.62 - 4137.93 \]
\[ 4137.93 = F_{AB} \cos 22.62 \]
\[ F_{AB} = \frac{4137.93}{\cos 22.62} \]

\[ \Sigma F_{BX} = 0 = R_{BX} + F_{ABX} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units; 1 point for stating tension

\[ F_{AB} = 4482.76 \text{ lbs.} \]
A positive answer shows an assumption of tensile force is correct.

Member AB is experiencing tension

[Diagram of Figure 1 and Figure 2]
2. A golf ball is launched at a 45° angle to the horizontal with an initial velocity of 50 ft/sec.

a) Determine the vertical component of the initial velocity. (answer precision = 0.00). [3 points]

\[ V_{iy} = V_i \sin \theta \]

\[ V_{iy} = 50 \text{ ft/sec} \left( \sin 45^\circ \right) \]

\[ V_{iy} = 50 \text{ ft/sec} \times 0.707 \]

\[ V_{iy} = 35.35 \text{ ft/sec} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units

b) Calculate the distance to where the golf ball will hit the ground. Use 32.15 ft/sec^2 for acceleration due to gravity. Neglect any air resistance and assume the ground is level. (answer precision = 0.00). [3 points]

\[ X = \frac{v_i^2 \sin 2\theta}{g} \]

\[ X = \frac{(50 \text{ ft/sec})^2 \sin(2(45^\circ))}{32.15 \text{ ft/sec}^2} \]

\[ X = 77.76 \text{ ft} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units
3. A tension test was conducted on a cylindrical specimen of titanium alloy. The gage length of the specimen was 2 in and the cross sectional area in the test region before loading was 1.57 in$^2$. Figure 4 shows the resulting Force - Displacement diagram.

Calculate the following quantities:

a) Stress at proportional limit. (answer precision = 0.00). [3 points]

\[ \sigma_{PL} = \frac{P_{PL}}{A} \]

\[ \sigma_{PL} = \frac{120000 \text{ lbs}}{1.57 \text{ in}^2} \]

\[ \sigma_{PL} = 76,433.12 \text{ psi} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units

b) Ultimate stress. (answer precision = 0.00). [3 points]

\[ \sigma_U = \frac{P_U}{A} \]

\[ \sigma_U = \frac{150000 \text{ lbs}}{1.57 \text{ in}^2} \]

\[ \sigma_U = 95,541.40 \text{ psi} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units

c) Starting at the origin and ending at the proportional limit, calculate the modulus of elasticity for this material. (answer precision = 0.00). [3 points]

\[ E = \frac{\Delta F \times L}{\Delta \delta \times A} \]

\[ E = \frac{120000 \text{ lbs} \times 2 \text{ in}}{0.01 \text{ in} \times 1.57 \text{ in}^2} \]

\[ E = 15,286,624.20 \text{ psi} \]

1 point for stating the formula
1 point for showing substitutions
1 point for the correct answer with correct units
4. The closed-loop program shown below is designed to differentiate between large, mid-size and small blocks, and then to turn on specific lamps according to those sizes. Study the program description and decide which of the program elements from the answer bank (A through I) must be used to complete the flowchart program. Write the letter of the correct icon in the proper empty box. No icon will be used more than once, and some may not be used at all. [4 points]

**Program Description:**
All Switches are wired normally open. When the program starts, conveyer M1 is turned on (CW). When limit switch I1 is pressed (turns from a 0 from a 1), conveyer M1 will stop. If limit switch I3 is pressed, it means a large block has been detected. This will turn lamp M2 ON. If limit switch I3 is not pressed, the computer will check limit switch I2. If switch I2 is pressed, it means a mid-size block has been detected. This will turn lamp M3 ON. If limit switch I2 is not pressed, a small block has been detected. This will turn lamp M4 ON. A delay of 5 seconds will occur. The computer will then check to make sure all switches are clear and then turn OFF all lamps that may have be ON.
5. Each of the following four statements represents a step in a design process. There are nine design process steps listed in the answer bank. Identify which of the steps from the answer bank is being represented by each statement by writing the step number on the line provided. [4 points]

a) A team of Principles of Engineering students run trials of their completed marble sorting device to assess how well it meets the design criteria.
   Identify the step in the design process: ___________ 8

b) Students will identify and agree on characteristics, parameters and constraints that a design must adhere to.
   Identify the step in the design process: ___________ 2

c) Students spend time individually to generate their design ideas in order to later share them with their team.
   Identify the step in the design process: ___________ 4

d) A team of Principles of Engineering students spend time developing technical drawings of their solution’s components before fabricating the design.
   Identify the step in the design process: ___________ 6

**Answer Bank**

<table>
<thead>
<tr>
<th>Step #</th>
<th>Design Process Step Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify the Problem</td>
</tr>
<tr>
<td>2</td>
<td>Define the Criteria</td>
</tr>
<tr>
<td>3</td>
<td>Research and Investigate</td>
</tr>
<tr>
<td>4</td>
<td>Generate Alternative Solutions</td>
</tr>
<tr>
<td>5</td>
<td>Choose a Solution</td>
</tr>
<tr>
<td>6</td>
<td>Refine and Develop the Solution</td>
</tr>
<tr>
<td>7</td>
<td>Model and Prototype the Solution</td>
</tr>
<tr>
<td>8</td>
<td>Test and Evaluate the Solution</td>
</tr>
<tr>
<td>9</td>
<td>Redesign and Improve the Solution</td>
</tr>
</tbody>
</table>
6. Study the technical drawing below, and sketch the missing object lines and hidden lines. There are two missing lines in each of the orthographic views. [6 points]

*Each view is worth a maximum of 2 points. 1 point for each correct line.*