1) Do not put your completed work on the floor next to you or anywhere else where it can be seen. If any part of your work can be seen by others it will be confiscated and you will not be permitted to rework those problems. Place it face down on your desk under your existing work.

2) Please remove your hat. If it is part of your head, turn it around backwards.

3) Your work must be legible and your logic must be clear, or the problem will receive zero credit. This paper will be written to acceptable engineering standards for credit.

4) You may work the exam on your own paper or on paper supplied at the front of the room.

5) All problems are of equal value.

DO NOT OPEN THIS QUIZ UNTIL INSTRUCTED TO DO SO
Quiz #1

Problem 1:

The steel truss shown is loaded with $P = 100$ kips. The engineer notes that as the dimension "x" is decreased, the lengths of the members shorten, thereby tending to reduce the weight of the structure. However, this also gives the members a shallower angle, increasing the forces in the members, thereby increasing the stress in the members and requiring additional cross-sectional area, which tends to increase the weight of the structure. Write an EES program which could be used to minimize the weight of the structure. Use $y = 30$ feet and a unit weight of $490$ #/ft$^3$. The allowed stress in the steel is $36$ ksi. If you have forgotten the equation for stress in an axially loaded rod, it is stress = $P/A$. Describe in general what you would do to minimize the weight of the structure once you got the program written. See next page for EES sheet. You can write your code on this sheet, or on the EES sheet, or on a blank sheet. If you do not remember the proper command to do something like round a number to an integer, you can make it up. I understand that if you were running the program you would be able to just look it up.

![Diagram of the truss structure]

Basic Solution:

1) Write equations using the method of joints to determine forces in members ac and bc, i.e. sum forces horizontal = 0, and sum forces vertical = 0.
2) Write equations for theta1 and theta2 in terms of X and Y
3) Write equations for lengths of members in terms of X and Y
4) Write equations for areas of members using stress = force in ac/Area ac and stress = force in bc/Area bc.
5) Write equations for weights of members in terms of lengths and areas.

Solution obtained by using the min/max function of EES, with X as the independent variable and the weight as the variable to be minimized.
Problem 1:

The steel truss shown is loaded with $P = 100$ kips. The engineer notes that as the dimension "x" is decreased, the lengths of the members shorten, thereby tending to reduce the weight of the structure. However, this also gives the members a shallower angle, increasing the forces in the members, thereby increasing the stress in the members and requiring additional cross-sectional area, which tends to increase the weight of the structure. Write an EES program which could be used to minimize the weight of the structure. Use $y = 30$ feet and a unit weight of 490 $^\#/$ft$^3$. The allowed stress in the steel is 36 ksi. If you have forgotten the equation for stress in an axially loaded rod, it is stress = $P/A$. Describe in general what you would do to minimize the weight of the structure once you got the program written. See next page for EES sheet. You can write your code on this sheet, or on the EES sheet, or on a blank sheet. If you do not remember the proper command to do something like round a number to an integer, you can make it up. I understand that if you were running the program you would be able to just look it up.

\[ P = 100'' \text{ kips} \]
\[ (\Sigma F_x) \quad 0 = +F \sin(\theta_1) + FBC \sin(\theta_2) - P \]
\[ (\Sigma F_y) \quad 0 = -F \cos(\theta_1) - FBC \cos(\theta_2) \]

\[ \text{STRESS} = \frac{F \text{AC}}{\text{AREA} \text{AC}} \]
\[ \text{STRESS} = \frac{F \text{BC}}{\text{AREA} \text{ABC}} \]
\[ \text{STRESS} = 36000 \times 144 \text{''}(\frac{^\#}{\text{in}^2})(\frac{\text{in}^2}{\text{ft}^2}) \]

\[ \tan(\theta_1) = \frac{x}{2 \ast y} \]
\[ \tan(\theta_2) = \frac{x}{y} \]
\[ L_{\text{AC}} = \sqrt{(x^2 + (y \ast y)^2)} \]
\[ L_{\text{BC}} = \sqrt{(x^2 + y^2 + z^2)} \]
\[ W_{\text{AC}} = \text{AAC} \ast L_{\text{AC}} \ast \text{DENSITY} \]
\[ W_{\text{BC}} = \text{ABC} \ast L_{\text{BC}} \ast \text{DENSITY} \]
\[ \text{TOTAL W} = \text{ABS}(W_{\text{AC}} + W_{\text{BC}}) \]
\[ \text{DENSITY} = 490 \text{ ''}/\text{ft}^3 \]
\[ Y = 30 \]
"QUIZ #1"

"To solve this problem using EES, you merely explain the rules to the program
For example, for varying values of x, define the angles theta1 and theta2
Then define how to solve for the forces in the members, using the method of joints,
, i.e. sum forces x = 0 and sum forces y = 0
Then define how to solve for the required cross-sectional areas to give the allowed stresses in the members
Then define the weights of the resulting members, and minimize that total weight"

\[
y = 30 \times 12 \quad \text{"inches"}
\]
\[
P = 100000 \quad \text{"pounds"}
\]
\[
\text{Density} = 490/1728 \quad \text{"pounds/cubic inch"}
\]
\[
\text{stress} = 36000 \quad \text{"pounds/in}^2\text{"}
\]
\[
0 = \text{fac} \times \sin(\theta_1) + \text{fbc} \times \sin(\theta_2) - P \quad \text{"pounds - sum forces horizontal = 0"}
\]
\[
0 = -\text{fac} \times \cos(\theta_1) - \text{fbc} \times \cos(\theta_2) \quad \text{"pounds - sum forces vertical = 0"}
\]
\[
\tan(\theta_1) = x/(2 \times y) \quad \text{"degrees"}
\]
\[
\tan(\theta_2) = x/y \quad \text{"degrees"}
\]
\[
\text{stress} = \text{fac} / \text{areaac} \quad \text{"pounds/in}^2\text{"}
\]
\[
\text{stress} = \text{fbc} / \text{areabc} \quad \text{"pounds/in}^2\text{"}
\]
\[
\text{Lac} = \sqrt{x^2 + (2 \times y)^2} \quad \text{"inches"}
\]
\[
\text{Lbc} = \sqrt{x^2 + y^2} \quad \text{"inches"}
\]
\[
\text{Wac} = \text{abs} \times \text{(Areaac} \times \text{Lac} \times \text{Density}) \quad \text{"Take absolute value to handle negative answers for member forces"}
\]
\[
\text{Wbc} = \text{abs} \times \text{(Areabc} \times \text{Lbc} \times \text{Density}) \quad \text{"pounds"}
\]
\[
\text{TotalW} = \text{Wac} + \text{Wbc}
\]

SOLUTION

\begin{itemize}
\item Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]
\item Minimization of TotalW(x) 18 iterations: Quadratic Approximations method
\end{itemize}

\[
\begin{align*}
\text{areaac} &= -4.811 \\
\text{fbc} &= -173207 \\
\text{Lbc} &= -623.5 \\
\text{theta1} &= 35.26 \\
\text{Wac} &= 1203 \\
\text{y} &= 360 \\
\text{areabc} &= 6.804 \\
\text{fbc} &= 244950 \\
\text{P} &= 100000 \\
\text{theta2} &= 54.74 \\
\text{Wbc} &= 1203 \\
\text{Density} &= 0.2836 \\
\text{Lac} &= 881.8 \\
\text{stress} &= 36000 \\
\text{TotalW} &= 2406 \\
\text{x} &= 509.1
\end{align*}
\]
Problem 2) I have a server in my office to let students download various files. Requests for files arrive exponentially distributed every 3 seconds between 7 am and 6 pm. For the remainder of the day requests arrive normally distributed with a mean of 6 seconds and a sigma = 1 second. The server requires a mean of 0.04 sec/Mb to serve files, with a sigma of 0.01 Mb/sec, distributed normally.

The requested file sizes are normally distributed, with a mean of 200 Mb, and a sigma of 30 Mb. Further, the files sizes require an even number of Mb space in memory, so you might wish to remember the FLOOR(x) command in BOSS where FLOOR(x) = the greatest integer <= x.

The server has a memory capacity of 1000 Mb available to serve files. If the file requests currently being processed exceed this capacity, further requests are delayed until the required memory is available. Files are processed in the order received.

Write a BOSS program to simulate this server.
PROGRAM
"file server"
"No points were deducted if you couldn't figure out how to make the
program run for over 1 day"
"Points WERE deducted if you didn't listen in class and know how to thin
out the arrivals"
"Change CAPACITY, file sizes, etc. listed below for the other quiz"

DEFINITION
serverram:RESOURCE = {CAPACITY = 2000}; "change capacity for other quiz"
ATTRIBUTES = {filesize = 0, daytime = 0}; "define filesize and daytime as
LOCAL variables"
LABELS = {timecheck1, timecheck2, depart1, depart2, getfile};

CONTROL
STOPTIME=360000; "run for about 4 days - in seconds"

LOGIC "start analysis at 7 am"
ARRIVE {TIME = EXPD(3)}; "born morning file requests"
daytime = CLOCKTIME; "must reset time after each 24 hour day"

timecheck1: IF daytime <= 24*60*60 THEN GOTO depart1;
daytime = daytime - 24*60*60; "take off a day"
GOTO timecheck1; "see if you need to take off another day"

depart1: IF daytime >= 11*60*60 THEN DEPART(); "get rid of evening requests"
GOTO getfile; "go get a file"

ARRIVE {TIME = 0 MAX NORMAL(6,1)}; "born evening file requests"
daytime = CLOCKTIME; "must reset time after each 24 hour day"

timecheck2: IF daytime <= 24*60*60 THEN GOTO depart2;
daytime = daytime - 24*60*60; "take off a day"
GOTO timecheck2; "see if you need to take off another day"

depart2: IF daytime <= 11*60*60 THEN DEPART(); "get rid of morning requests"
GOTO getfile; "go get a file"

getfile: filesize = 0 MAX NORMAL(200,30); "assign random filesize - a personal
attribute for each request"
filesize = FLOOR(filesize) + 1; "truncate filesize and add 1"
"or, filesize = CEILING(filesize); which will round filesize up"
SEIZE{NAME = serverram, UNITS = filesize}; "seize ram from server"
WAIT{TIME = 0 MAX NORMAL(0.04*filesize, 0.01*filesize)}; "wait while
server hands off file"
RELEASE{NAME = serverram, UNITS = filesize}; "release server memory
capacity"
DEPART();

END.
Problem 3) Solve the following problem graphically:

Max \( Z = 3x + 2y \)

ST \( 6x - 5x^2 - y \leq 0 \)
\( 3x - 2x^2 - y \geq 0 \)

For your convenience I have plotted a couple of curves for you. If you think they are useful, you may use them. Or not.

The upper curve is \( 6x - 5x^2 - y = 0 \).
The bottom curve is \( 3x - 2x^2 - y = 0 \).

Basic Solution:

1) Determine which side of the equation \( 6x - 5x^2 - y = 0 \) is illegal - turns out to be that area under the curve. Scratch it out.
2) Determine which side of the equation \( 3x - 2x^2 - y = 0 \) is illegal - turns out to be that area above the curve. Scratch it out.
3) The remaining area is the feasible region.
4) Plot the objective function \( Z = 3x + 2y \) using several arbitrary values for \( Z \), to get the slope of the line.
5) Move that line up until it no longer touches within the feasible region and that point is the answer.
1. For $x = 0.5, y = 1.5$:
\[
g(0.5) - 5(0.5)^2 - 1.5 = 0.25
\]
\[
0.25 \leq 0 \text{ NO, illegal side}
\]

2. For $x = 0.5, y = 2$:
\[
g(0.5) - 5(0.5)^2 - 2 = -0.25
\]
\[
-0.25 \leq 0 \text{ YES}
\]

For $x = 0.5, y = 1.5$:
\[
3(0.5) - 2(0.5)^2 - 1.5 = -0.5 \geq 0 \text{ NO, so illegal side}
\]

\[
\text{Max } Z = 3X + 2Y = 0.5 \Rightarrow \text{try } Z = 0.5
\]
\[
3(0) + 2(0) = 0.5, y = 0.25
\]
\[
3(0) + 2(0) = 0.5, x = 0.167
\]
\[
\underline{Z} = 3X + 2Y = 1.0 \Rightarrow \text{try } Z = 1.0
\]
\[
3(0) + 2(1) = 1, y = 1/2
\]
\[
3(0) + 2(0) = 1, x = 0.33
\]

Answer: $X = 1.1, Y = 0.9, Z = 5.1$
Problem 4) Identify any errors in the BOSS code below. State which line the error is on.

1] PROGRAM "Final Spring 2007a"
2] DEFINITION
3] count=0;
4] LABELS = {dog, pig};
5] CONTROL
6] STOPTIME=8*60;
7] LOGIC
8] ARRIVE {TIME = EXP(6)}; ⇒ EXPD
9] count = count+1;
10] dog: IF(count <= 6) THEN GOTO pig;
11] GOTO dog; ⇒ Zero time loop back to dog
12] ARRIVE {TIME = NORMAL(6,3)}; ⇒ Should be 0 MAX NORMAL(6,3)
13] pig: count = count+3 ⇒ Missing ; at end of line
14] SEIZE {NAME = cat, UNITS = 2}; ⇒ cat is not defined as a resource
15] WAIT {TIME = 1};
16] IF count >= 2 THEN DEPART {} ELSE GOTO dog;⇒ Depart without releasing resource
17] count = count+4; ⇒ Can never get to this line of code
18] GOTO dog;
19] END.
Problem 5) I have purchased the rights to a Little Richard record for $P = 8$ million dollars. My yearly income is from this investment is expected to come in as shown below. If my MARR was 6% what is my expected value of $Y$?

Basic Solution:

1) Change the gradient $Y/6$ to a single value of $P_1$ at 0 years
2) Same thing for the remaining gradients, at 10, 20, 30, ... years
3) Change the value of $P_1$ to a 10 year $A_0$, thereby making $A$ a continuous yearly value forever
4) Get $P = A/i$, so $8,000,000 = A/i$.

Just that simple.
Problem 5: I have purchased the rights to a Little Richard record for 8 million dollars. My yearly income from this investment is expected to come in as shown below. If my MARR was 6% what is my expected value of $Y$?

\[
T = \frac{Y \left[ \frac{P}{G}, 6\%, 7 \right]}{6} = \frac{15.4497}{6} = 2.57495Y
\]

\[
A = T \left[ \frac{A}{P}, 6\%, 10 \right] = 0.1359 \left( \frac{A}{P}, 6\%, 10 \right) = 0.1359(2.57495Y) = 0.34994Y
\]

\[
P = \frac{A}{i} = \frac{0.34994Y}{0.06} = \frac{8,000,000}{5.83} = \#1,372,212.69
\]
Quiz #2

Problem 1) The city of Bryan has floated a $P = 80$ million dollar bond to fund repairs on their courthouse for eternity. The money will be invested at 6% and withdrawn yearly for repairs as shown below. Solve for the expected value of $Y$.

Basic Solution:

1) Change the gradient $Y/6$ to a single value of $P1$ at 0 years
2) Same thing for the remaining gradients, at 10, 20, 30, … years
3) Change the value of $P1$ to a 10 year $A$, thereby making $A$ a continuous yearly value forever
4) Get $P = A/i$, so $80,000,000 = A/i$.

Just that simple.
Problem 1) The city of Bryan has floated an 80 million dollar bond to fund repairs on their courthouse for eternity. The money will be invested at 6% and withdrawn yearly for repairs as shown below. Solve for the expected value of G.

See Problem #5, Quiz #1
Same problem *10
Problem 1) The city of Bryan has floated a $P = 80$ million dollar bond to fund repairs on their courthouse for eternity. The money will be invested at 6% and withdrawn yearly for repairs as shown below. Solve for the expected value of $Y$.

\[
\text{Interest on } 80M = 80(1 + .06)^{10} - 80 = 63.2678M
\]

\[
Y = 80(F_{0.06, 10}) + (\frac{Y}{6})(F_{0.06, 7})(F_{0.06, 3}) = 80
\]

\[
80(1.7908) - (\frac{Y}{6})(23.2306)(1.1910) = 80
\]

\[
Y = 13.7194\text{ Million}
\]
Problem 2) Identify any errors in the BOSS code below. State which line the error is on.

1] PROGRAM
2] "Final Spring 2007a"
3]
4] DEFINITION
5]     count=0;
6]     LABELS = {dog, pig};
7]
8] CONTROL
9]     STOPTIME=8*60;
10]
11] LOGIC
12]
13] ARRIVE {TIME = NORMAL(6,3)};  \[ Should be 0 MAX NORMAL(6,3)
14]     pig: count = count+3  \[ Missing ; at end of line
15]     SEIZE {NAME = cat, UNITS = 2};  \[ cat is not defined as a resource
16]     WAIT {TIME = 1};
17]     IF count >= 2 THEN DEPART{} ELSE GOTO dog;  \[ Depart without releasing resource
18]     count = count+4;  \[ Cannot get to this line of code
19]     GOTO dog;
20]
21] ARRIVE {TIME = EXP(6)};  \[ EXPD
22]     count = count+1;
23] dog: IF(count <= 6) THEN GOTO pig;
24]     GOTO dog;  \[ Zero time loop
25]
26] END.
Problem 3) Solve the following problem graphically:

Max $Z = 2x + 3y$

ST  \[3x - 2x^2 - y \leq 0\]
    \[6x - 5x^2 - y \geq 0\]

For your convenience I have plotted a couple of curves for you. If you think they are useful, you may use them. Or not.

The upper curve is $6x - 5x^2 - y = 0$.
The bottom curve is $3x - 2x^2 - y = 0$.

Basic Solution:

1) Determine which side of the equation $6x - 5x^2 - y = 0$ is illegal - turns out to be that area above the curve. Scratch it out.
2) Determine which side of the equation $3x - 2x^2 - y = 0$ is illegal - turns out to be that area under the curve. Scratch it out.
3) The remaining area is the feasible region.
4) Plot the objective function $Z = 3x + 2y$ using several arbitrary values for $Z$, to get the slope of the line.
5) Move that line up until it no longer touches within the feasible region and that point is the answer.
1) For \( x = 0.5 \), \( y = 0.5 \)
\[ 3x - 2y^2 - y = 3(0.5) - 2(0.5)^2 - 0.5 = 0.5 \]
0.5 < 1.10
So, illegal.
Inside

2) For \( x = 0.5 \), \( y = 0.5 \)
\[ 6(0.5) - 5(0.5)^2 - 0.5 = 1.25 > 0 \] so legal.
Inside

Max \( Z = 2x + 3y \)
\[ 2(0) + 3(0.33) = 1 \]
\[ 2(0.5) + 3(0) = 1 \]

Answer: \( x = 0.7 \), \( y = 1.75 \), \( Z = 6.65 \)
Problem 4) I have a server in my office to let students download various files. Requests for files arrive exponentially distributed every 5 seconds between 7 am and 6 pm. For the remainder of the day requests arrive normally distributed with a mean of 8 seconds and a sigma = 1 second. The server requires a mean of 0.08 sec/Mb to serve files, with a sigma of 0.02 Mb/sec, distributed normally.

The requested file sizes are normally distributed, with a mean of 400 Mb, and a sigma of 60 Mb. Further, the files sizes require an even number of Mb space in memory, so you might wish to remember the CEILING(x) command in BOSS where CEILING(x) = the smallest integer >= x.

The server has a memory capacity of 2000 Mb available to serve files. If the file requests currently being processed exceed this capacity, further requests are delayed until the required memory is available. Files are processed in the order received.

Write a BOSS program to simulate this server.

SEE PROBLEM #2, QUIZ #1
CHANGE A FEW CONSTANTS
Problem 5)

The steel truss shown is loaded with P = 100 kips. The engineer notes that as the dimension “x” is decreased, the lengths of the members shorten, thereby tending to reduce the weight of the structure. However, this also gives the members a shallower angle, increasing the forces in the members, thereby increasing the stress in the members and requiring additional cross-sectional area, which tends to increase the weight of the structure. Write an EES program which could be used to minimize the weight of the structure. Use y = 30 feet and a unit weight of 490 #/ft³. The allowed stress in the steel is 42 ksi. If you have forgotten the equation for stress in an axially loaded rod, it is stress = P/A. Describe in general what you would do to minimize the weight of the structure once you got the program written. See next page for EES sheet. You can write your code on this sheet, or on the EES sheet, or on a blank sheet. If you do not remember the proper command to do something like round a number to an integer, you can make it up. I understand that if you were running the program you would be able to just look it up.

Basic Solution:

1) Write equations using the method of joints to determine forces in members ac and bc, i.e. sum forces horizontal = 0, and sum forces vertical = 0.
2) Write equations for theta1 and theta2 in terms of X and Y
3) Write equations for lengths of members in terms of X and Y
4) Write equations for areas of members using stress = force in ac/Area ac and stress = force in bc/Area bc.
5) Write equations for weights of members in terms of lengths and areas.

Solution obtained by using the min/max function of EES, with X as the independent variable and the weight as the variable to be minimized.

See Quiz #1 for free bodies
"QUIZ #2"

"To solve this problem using EES, you merely explain the rules to the program
For example, for varying values of x, define the angles theta1 and theta2
Then define how to solve for the forces in the members, using the method of joints,
, i.e. sum forces x = 0 and sum forces y = 0
Then define how to solve for the required cross-sectional areas to give the allowed stresses in the members
Then define the weights of the resulting members, and minimize that total weight"

\[ y = 30*12 \text{ "inches"} \]
\[ P = 100000 \text{ "pounds"} \]
\[ \text{Density} = 490/1728 \text{ "pounds/cubic inch"} \]
\[ \text{stress} = 42000 \text{ "pounds/in}^2\text{"} \]

\[ 0 = \text{fac} \sin(\theta_1) + \text{fbc} \sin(\theta_2) - P \text{ "pounds - sum forces horizontal = 0"} \]
\[ 0 = -\text{fac} \cos(\theta_1) - \text{fbc} \cos(\theta_2) \text{ "pounds - sum forces vertical = 0"} \]

\[ \tan(\theta_1) = x/(y + y/2) \text{ "degrees"} \]
\[ \tan(\theta_2) = x/(y/2) \text{ "degrees"} \]

\[ \text{stress} = \text{fac}/\text{areaa} \text{ "pounds/in}^2\text{"} \]
\[ \text{stress} = \text{fbc}/\text{areabc} \text{ "pounds/in}^2\text{"} \]

\[ \text{Lac} = \sqrt{x^2 + (1.5*y)^2} \text{ "inches"} \]
\[ \text{Lbc} = \sqrt{x^2 + (y/2)^2} \text{ "inches"} \]
\[ \text{Wac} = \text{abs(Areaa}^\text{Lac} \text{Density}) \text{ "Take absolute value to handle negative answers for member forces"} \]
\[ \text{Wbc} = \text{abs(Areabc}^\text{Lbc} \text{Density}) \text{ "pounds"} \]

\[ \text{TotalW} = \text{Wac} + \text{Wbc} \]

**SOLUTION**

Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]

Minimization of TotalW(x) 19 iterations: Quadratic Approximations method

| \text{areaa} | -2.381 |
| \text{fac} | -99998 |
| \text{Lbc} | 360 |
| \text{theta1} | 30 |
| \text{Wac} | 421 |
| \text{y} | 360 |

| \text{areabc} | 4.124 |
| \text{fbc} | 173204 |
| \text{P} | 100000 |
| \text{theta2} | 60 |
| \text{Wbc} | 421 |

\[ \text{Density} = 0.2836 \]
\[ \text{Lac} = 623.5 \]
\[ \text{stress} = 42000 \]
\[ \text{TotalW} = 842 \]
\[ x = 311.8 \]