ENGR 1020 Freshman Engineering Seminar Final Assessment Key

215 total possible points (including Extra Credit)
175 total points

6 points 1) Name 6 TSU College of Engineering undergraduate degree programs.

Degree programs:
Aeronautical and Industrial Technology
Civil and Architectural Engineering
Computer Science
Electrical and Computer Engineering
Mathematical Sciences
Mechanical and Manufacturing Engineering

Emphasis programs:
Biomedical Engineering
Computer Engineering
Manufacturing Engineering

1 point 2) FALSE
The following groups are bound by the engineering code of ethics: graduates of engineering programs, Professional Engineers, land surveyors, and nongraduates of engineering programs.

%^ Relative to the engineering profession, the code of ethics applies to Degreed engineers, Licensed engineers, and Land Surveyors.

1 point 3) FALSE
The engineering practice of ethical obligations is to protect the environment (Earth’s ecosystems and the basis for human societies), human beings, and the prosperity of human beings from both injury and harm.

@^ Engineers, in the fulfillment of their professional duties, shall:
1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

1 point $4) FALSE
1 point 5) What is the name of the exam that you can take as a senior undergraduate student, in an accredited engineering program, that leads to the possibility of professional engineering registration?

!! National Council of Examiners for Engineering Surveying (NCEES) Fundamentals of Engineering (FE) Examination

1 point 6) After you take and pass the exam in Problem 5) you are given a registration certificate, what is the name of the certification?

!! Engineer Intern (EI) certificate/Engineer in Training (EIT) certificate

1 point 7) In order to sit for the Principles and Practice of Engineering Examination, what 2 things must you have already completed?

@@ Graduate with an ABET-approved undergraduate degree (4-year degree) in an engineering discipline and have your EI/EIT certificate
Work 4 years under the direction of a licensed Professional Engineer (PE) in your engineering discipline (progressive engineering experience)
Register as an applicant for the Professional Engineer license with the Commonwealth/State Board of Architectural and Engineering Examiners or its equivalent

7 points 8) Name 7 of the sections required by the TSU College of Engineering Problem Solving format?

Heading
Problem Statement
Given
Find
Assumption(s)
Equation(s)
Solution(s)

2 points 9) If a person driving a car is traveling at 1345.19 Mm/day, what is their speed in miles/sec?

MmTOmiles <- 621.37119 ## miles
DayTosec <- 86400 ## seconds
car <- **1345.19** ## Mm/day

```
car_US <- (car * MmTOmiles) / DayTosec
car_US
```

```r
## [1] 9.674332
```

Using ConvertAll 1345.19 Mm/day = 9.6743323 miles/sec.

2 points 10) If variable1 = 0.36875, what is the value of answer1, where answer1 = 12439.6variable1^9 + 162.85variable1^4 - 20.3285variable1^2 + 733.2024variable1 - 0.60458713?

```
variable1 <- 0.36875
var1 <- variable1
answer1 <- 12439.6*var1^9 + 162.85*var1^4 - 20.3285*var1^2 + 733.2024*var1 - 0.60458713
answer1
```

```r
## [1] 271.5788
```

[4 points total] 11)

1 point 11) a) In R, the following is typed on the command line:

```
single <- **10.4321:45.0000000000000045**
single
```

```r
## [25] 34.4321 35.4321 36.4321 37.4321 38.4321 39.4321 40.4321 41.4321
## [33] 42.4321 43.4321 44.4321
```

1 point 11) b) In R, the following is typed on the command line:

```
Single
Error: object 'Single' not found
```

1 point 11) c) In R, the following is typed on the command line:

```
singles = seq(10.4321, 45.0000000000000045, by = 12)
singles
```

```r
## [1] 10.4321 22.4321 34.4321
```

1 point 11) d) In R, the following is typed on the command line:
[11 points total] 12) Find Team Norms and Communication: Senior Design 2006 Resources: Mechanical Engineering at the University of Delaware on the class Web page: http://www.ecoccs.com/tsuteach.html. Read the first 5 pages of the document in order to answer the following questions:

1 point 12) a) **FALSE**
Reacting to the person speaking is an effective listening behavior.

%%% React to ideas, not to the person speaking.

1 point 12) b) **FALSE**
Verbal communication is the most important part of face-to-face or in-person communication.

%%% The figure below illustrates a very important finding: in face-to-face communication, the words used contribute less than 10% of a communication — non verbal visual and auditory signals communicate over 90% of the content!

1 point 12) c) **TRUE**
Future engineering employers care about their potential employee’s ability to effectively communicate.

1 point 12) d) **FALSE**
The intention of the listener/reader and the intention of the speaker/author do not matter in engineering communications.

%%% Communication is more than what we say or even what we mean to say. It is what our listeners think they heard and what they think we meant. Our intentions may not equal their perceptions. What they heard may not be what we meant. What eventually lodges in each person’s mind has as much to do with our internal filters, the mood we are in, when the conversation took place as it does with words actually spoken. These factors should be taken into account when clear communication is the goal. Communication is a total of all the things said – and not said.

4 points 12) e) Name all of the types of communication found in the Lecture Notes.

Graphical or Technical, Verbal, Nonverbal, Written

1 point 12) f) **FALSE**
It is a good idea to have numbers, special characters, and/or use personal nicknames in a professional electronic mail (e-mail) address.
It is a good idea to have your first and last name only in a professional electronic mail (e-mail) address.

1 point 12) g) FALSE
It is a good idea to not solely have a combination of your first and last name in a professional electronic mail (e-mail) address.

It is a good idea to have your first and last name only in a professional electronic mail (e-mail) address.

1 point 12) h) TRUE
It is a good idea to include the course number and your name in the subject of an electronic mail (e-mail) message to one of your professors.

3 points 13) Based on the following figure, what information is missing, if anything, based on the Lecture 5a Notes?

Corrected figure is below

```r
xlab <- "Miles per US gallon"
ylab <- "Weight (lb/1000)"
main <- "Fuel Consumption versus Weight for 32 Automobiles (1973-1974 models)"
qplot(mpg, wt, data = mtcars, xlab = xlab, ylab = ylab, main = main)
```
[4 points total] *14) “... In all of these cases, the agenda to recycle has superseded other design considerations. Just because a material is recycled does not automatically make it ecologically benign, especially if it was not designed specifically for recycling. Blindly adopting superficial environmental approaches without fully understanding their effects can be no better—and perhaps even worse—than doing nothing. ...

2 points 14) a) With regards to engineering ethics, should engineers care about the whole life cycle of the products that we design? Why or why not? (Answer in complete sentences)

2 points 14) b) Do you agree with the above excerpt from Cradle to Cradle: Remaking the Way We Make Things by William McDonough & Michael Braungart? Why or why not? (Answer in complete sentences)
Based on the following data set,

9 points 15) a) what are the values of the measures of central tendency for Beryllium-7?

```
load(url("http://www.ecoccs.com/raddata_Nash.RData"))
B7 <- subset(raddata_Nash, raddata_Nash$"ANALYTE_NAME" == "Beryllium-7")

mean(B7$"RESULT_AMOUNT") ## units of PCI/L
## [1] 56.96667

median(B7$"RESULT_AMOUNT") ## units of PCI/L
## [1] 51.35

library(DescTools)

## Loading required package: manipulate

Mode(B7$"RESULT_AMOUNT")
## [1] 19.0 31.1 41.2 61.5 64.0 125.0

## Here, all of the values occur once with units of PCI/L so there is not a true mode.
```

8 points 15) b) what are the measures of dispersion for Beryllium-7?

```
load(url("http://www.ecoccs.com/raddata_Nash.RData"))
B7 <- subset(raddata_Nash, raddata_Nash$"ANALYTE_NAME" == "Beryllium-7")

var(B7$"RESULT_AMOUNT") ## units of PCI/L ^ 2
## [1] 1411.539

sd(B7$"RESULT_AMOUNT") ## units of PCI/L
## [1] 37.57045
```

http://www.ecoccs.com/raddata_Nashville.csv is the link to the data in csv format
http://www.ecoccs.com/raddata_Nash.RData is the link to the data in RData format (only viewable through R or RStudio and is best viewed using library(data.table))

[17 points total] @!16) Based on the following data set,

9 points 16) a) what are the values of the measures of central tendency for Lead-212?

```
```r
load(url("http://www.ecoccs.com/fukushima_leads.RData"))
mean(fukushima_leads$"Result Amount") # units of PCI/M^3

## [1] 20.962

median(fukushima_leads$"Result Amount") # units of PCI/M^3

## [1] 3.75

library(DescTools)
Mode(fukushima_leads$"Result Amount")

## [1] 0.63 2.05 2.20 2.34 3.70 3.80 3.90 28.00 37.00 126.00

## Here, all of the values occur once with units of PCI/M^3 so there is not a true mode.

8 points 16) b) what are the measures of dispersion for Lead-212?

load(url("http://www.ecoccs.com/fukushima_leads.RData"))

var(fukushima_leads$"Result Amount") # units of PCI/M^3 ^ 2

## [1] 1521.467

sd(fukushima_leads$"Result Amount") # units of PCI/M^3

## [1] 39.00598

http://www.ecoccs.com/fukushima_leads.csv is the link to the data in csv format
http://www.ecoccs.com/fukushima_leads.RData is the link to the data in RData format (only viewable through R or RStudio and is best viewed using library(data.table)

[17 points total] @!17) Based on the following data set,
9 points 17) a) what are the values of the measures of central tendency for Thallium-208?

load(url("http://www.ecoccs.com/fukushima_thalliums.RData"))
mean(fukushima_thalliums$"Result Amount") # units of PCI/M^3

## [1] 14.0535
```
\textbf{median}(\texttt{fukushima_thalliums}\$"\texttt{Result Amount"}) ## units of PCI/M^3

\#
\#
\#

\texttt{library(DescTools)}
\texttt{Mode(}\texttt{fukushima_thalliums}\$"\texttt{Result Amount"})

\#
\#
\#

\texttt{library(data.table)}

\[10 \text{ points total} \] #18) It is known that the tensile strength of a plastic increases as a function of time it is heat treated. The following data is collected:

<table>
<thead>
<tr>
<th>Time</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>40</th>
<th>50</th>
<th>55</th>
<th>60</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>5</td>
<td>20</td>
<td>18</td>
<td>40</td>
<td>33</td>
<td>54</td>
<td>70</td>
<td>60</td>
<td>78</td>
</tr>
</tbody>
</table>

5 points 18) a) Fit a straight line to this data and use the equation to determine the tensile strength at a time of 63.5 min.

\texttt{library(pracma)}

\#
\#
\#

\#
\#
\#

\#
\#
\#

\#
\#
\#

\#
\#
\#
library(ggplot2)
Time <- c(10, 15, 20, 25, 40, 50, 55, 60, 75) ## minutes

Tensile_Strength <- c(5, 20, 18, 40, 33, 54, 70, 60, 78) ## units

lm.p <- lm(Tensile_Strength ~ Time) ## linear model
coef(lm.p) ## coefficients of linear model

## (Intercept)     Time
##  0.8179348  1.0589674

lm.p

##
## Call: lm(formula = Tensile_Strength ~ Time)
##
## Coefficients:
## (Intercept)     Time
##  0.8179     1.0590

summary(lm.p) ## summary of linear model

##
## Call: lm(formula = Tensile_Strength ~ Time)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -10.177 -4.356  -2.240  3.298  12.708
##
## Coefficients:

|                | Estimate | Std. Error | t value | Pr(>|t|) |
|----------------|----------|------------|---------|----------|
| (Intercept)    | 0.8179   | 5.7230     | 0.143   | 0.89     |
| Time           | 1.0590   | 0.1290     | 8.206   | 7.75e-05 *** |

---

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 8.252 on 7 degrees of freedom  
Multiple R-squared: 0.9058, Adjusted R-squared: 0.8924  
F-statistic: 67.34 on 1 and 7 DF,  p-value: 7.747e-05

```r
df <- data.frame(Time, Tensile_Strength)  
library(ggplot2)

## Source <https://gist.github.com/kdauria/524eade46135f6348140>

## Quoted source: r - ggplot2: Adding Regression Line Equation and R2 on graph - Stack Overflow answered by kdauria on Jan 15 2015 and edited by kdauria on Mar 14 2015.


## Slightly modified from original version (text in variable names)

library(proto)

stat_smooth_func <- function(mapping = NULL, data = NULL, geom = "smooth", position = "identity", method = "auto", formula = y ~ x, se = TRUE, n = 80, fullrange = FALSE, level = 0.95, na.rm = FALSE, ...) {
  StatSmoothFunc$new(mapping = mapping, data = data, geom = geom, position = position, method = method, formula = formula, se = se, n = n, fullrange = fullrange, level = level, na.rm = na.rm, ...)
}

StatSmoothFunc <- proto(ggplot2:::Stat, {
  objname <- "smooth"

  calculate_groups <- function(.x, data, scales, method="auto", formula=y~x, ...) {
    rows <- dplyr(data, .(group), function(df) length(unique(df$x))
    if (all(rows == 1) & length(rows) > 1) {
      message("geom_smooth: Only one unique x value each group."
      "Maybe you want aes(group = 1)?")
      return(data.frame())
    }

    ## Figure out what type of smoothing to do: loess for small datasets,
    ## gam with a cubic regression basis for large data
    ## This is based on the size of the _largest_ group.
    if (identical(method, "auto")) {
      groups <- count(data, "group")
```
if (max(groups$freq) < 1000) {
    method <- "loess"
    message('geom_smooth: method="auto" and size of largest group is <1000,'
          ' so using loess.',
          ' Use \'method = x\' to change the smoothing method."
    }
} else {
    method <- "gam"
    formula <- y ~ s(x, bs = "cs")
    message('geom_smooth: method="auto" and size of largest group is >=1000,'
          ' so using gam with formula: y ~ s(x, bs = "cs").',
          ' Use \'method = x\' to change the smoothing method."
    }
}
if (identical(method, "gam")) try_require("mgcv")

.super$calculate_groups(., data, scales, method = method, formula = formula, ...)

calculate <- function(., data, scales, method="auto", formula=y~x, se = TRUE, n=80, fullrange, ...)
  data <- remove_missing(data, na.rm, c("x", "y"), name="stat_smooth")
  if (length(unique(data$x)) < 2) {
    ## Not enough data to perform fit
    return(data.frame())
  }
  if (is.null(data$weight)) data$weight <- 1
  if (is.null(xseq)) {
    if (is.integer(data$x)) {
      if (fullrange) {
        xseq <- scale_dimension(scales$x, c(0, 0))
      } else {
        xseq <- sort(unique(data$x))
      }
    } else {
      if (fullrange) {
        range <- scale_dimension(scales$x, c(0, 0))
      } else {
        range <- range(data$x, na.rm=TRUE)
      }
      xseq <- seq(range[1], range[2], length=n)
    }
  }
  if (is.character(method)) method <- match.fun(method)
  method.special <- function(...) {
    method(formula, data=data, weights=weight, ...)
  }
  model <- safe.call(method.special, list(...), names(formals(method)))
predictdf(model, xseq, se, level)
m = model
eq <- substitute(italic(Tensile_Strength) == a + b %.% italic(Time)*",""-%italic(r)^2"=")-
list(a = format(coef(m)[1], digits = 3),
b = format(coef(m)[2], digits = 3),
r2 = format(summary(m)$r.squared, digits = 3))
func_string = as.character(as.expression(eq))

data.frame(x=min(data$x)*0.9, y=max(data$y)*0.9, label=func_string)
}

required_aes <- c("x", "y")
default_geom <- function(.) GeomSmooth

p <- ggplot(data = df, aes(x = Time, y = Tensile_Strength, label = Tensile_Strength))
p <- p + stat_smooth_func(geom = "text", method = "lm", hjust = 0, parse = TRUE)
p <- p + geom_smooth(method = "lm", se = FALSE) + geom_point()
p <- p + labs(list(title = "Heat Treatment of Plastic", x = "Time", y = "Tensile Strength"))
print(p)
## The tensile strength at 63.5 minutes:

```r
Time63.5 <- 63.5
Tensile_Strength63.5min <- coef(lm.p)[[2]] * Time63.5 + coef(lm.p)[[1]]
Tensile_Strength63.5min
```

## [1] 68.06236

3 points 18) b) Use linear interpolation to find the tensile strength at a time of 63.5 minutes.

```r
library(pracma)

xi <- 63.5 ## minutes
Tensile_Strength63.5_Interpolation <- interp1(Time, Tensile_Strength, xi, method = "linear")
Tensile_Strength63.5_Interpolation
```

## [1] 64.2

2 points 18) c) Assuming that the answer in a) is the true value, then what is the relative error?

```r
relerror <- function (xtrue, xapprox) {
##
##
relerror <- ((xtrue - xapprox) / xtrue) * 100 ## relative error

cat("The relative error is", paste(round(relerror)), ", ", "\%.\n")

return(relerror)

}

relerror(Tensile_Strength63.5min, Tensile_Strength63.5_Interpolation)
```

## The relative error is 6 \%

## [1] 5.674743

[6 points total] 19) Regarding the Error Analysis of Launch Data (from Lecture 6 Notes),

2 points 19) a) why is the average error calculation misleading?

The calculated average error is -1 m which is misleading because it makes someone think that most launches hit either 99 m or 101 m. This is not true in the case of this data.
2 points 19) b) why is the square root of the average of the square of the error a better indicator of the accuracy of the launcher than the average error?

9.27 m is a better indicator of the error than -1 m. Most of the trials are within ±10 m off of the mark of 100 m.

2 points 19) c) how does the standard deviation value compare with the results from Part (c) [from Lecture 6 Notes]? 

Standard deviation is 9.72 m, which is close to the the square root of the average of the square of the error estimate of 9.27 m.

[10 points total] 20)

4 points 20) a) Fill in the table with the missing information:

Counts or frequencies of launch distances sorted into bins.

<table>
<thead>
<tr>
<th>bid ID, i</th>
<th>range</th>
<th>count, N(i)</th>
<th>probability, P(i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>14 ≤ d &lt; 15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>15 ≤ d &lt; 16</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>16 ≤ d &lt; 17</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>17 ≤ d &lt; 18</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>18 ≤ d &lt; 19</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>19 ≤ d &lt; 20</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14 ≤ d &lt; 20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

3 points 20) b) Use a histogram to plot the count per distance.

3 points 20) c) Use a histogram to plot the probability per distance.

```r
bid_ID <- c(14:20)
count <- c(1, 3, 4, 7, 2, 3, 20)
probability <- count / 20

## Use a histogram to plot the count per distance & the probability per distance.
biddf <- data.frame(bid_ID, count, probability)
biddf
```

```r
#   bid_ID count probability
# 1    14   1  0.05
# 2    15   3  0.15
```
## 3 16 4 0.20
## 4 17 7 0.35
## 5 18 2 0.10
## 6 19 3 0.15
## 7 20 20 1.00

colnames(biddf) <- c("bid ID", "count", "probability")

count2 <- count[1:6]
probability2 <- probability[1:6]
biddf2 <- biddf[1:6, ]

library(ggplot2)
p <- ggplot(biddf2, aes(x = bid_ID2, y = count2)) + geom_bar(stat = "identity", width = 0.5)
p <- p + labs(title = "Frequency of Launch Distances", x = "Distance, m")
p <- p + scale_x_continuous(breaks = 14:19)
print(p)

Frequency of Launch Distances

p <- ggplot(biddf2, aes(x = bid_ID2, y = probability2))
p <- p + geom_bar(stat = "identity", width = 0.5)
p <- p + scale_x_continuous(breaks = 14:19)
p <- p + labs(title = "Probability of Launch Distances", x = "Distance, m")
print(p)
2 points %21) The supervisor of a group of 20 construction workers wants to get the opinion of 2 of them (to be selected at random) about certain new safety regulations. If 12 of them favor the new regulations and the other 8 are against it, what is the probability that both of the workers chosen by the supervisor will be against the new safety regulations?

**library(prob)**

```r
## Loading required package: combinat
##
## Attaching package: 'combinat'
##
## The following object is masked from 'package:pracma':
##
## fact
##
## The following object is masked from 'package:utils':
##
## combn
##
## Loading required package: fAsianOptions
## Loading required package: timeDate
## Loading required package: timeSeries
## Loading required package: fBasics
##
## Rmetrics Package fBasics
## Analysing Markets and calculating Basic Statistics
## Copyright (C) 2005-2014 Rmetrics Association Zurich
## Educational Software for Financial Engineering and Computational Science
## Rmetrics is free software and comes with ABSOLUTELY NO WARRANTY.
## https://www.rmetrics.org --- Mail to: info@rmetrics.org
##
## Attaching package: 'fBasics'
##
```
## The following objects are masked from 'package:pracma':
##
## akimaInterp, inv, kron, pascal
##
## Loading required package: fOptions
##
## Rmetrics Package fOptions
## Pricing and Evaluating Basic Options
## Copyright (C) 2005-2014 Rmetrics Association Zurich
## Educational Software for Financial Engineering and Computational Science
## Rmetrics is free software and comes with ABSOLUTELY NO WARRANTY.
## https://www.rmetrics.org --- Mail to: info@rmetrics.org
##
## Attaching package: 'fAsianOptions'
##
## The following object is masked from 'package:pracma':
##
## erf
##
## Loading required package: hypergeo
## Loading required package: VGAM
## Loading required package: stats4
## Loading required package: splines
##
## Attaching package: 'VGAM'
##
## The following object is masked from 'package:hypergeo':
##
## is.zero
##
## The following object is masked from 'package:fAsianOptions':
##
## erf
##
## The following objects are masked from 'package:pracma':
##
## erf, erfc, expint, logit, loglog, Rank, zeta
##
##
## Attaching package: 'prob'
##
## The following objects are masked from 'package:base':
##
## intersect, setdiff, union

## Probability of A
workers <- rep(c("Against", "Favor"), times = c(8, 12))
## Create workers of 8 against and 12 favor
workerssample <- urnsamples(workers, size = 1, replace = FALSE, ordered = FALSE)
Create a sample space of picking 1 worker where there is no replacement and the order does not matter:

```r
workersampleProbspace <- probspace(workerssample)
```

Probability space of all events occurring:

```r
workerssampleProb <- Prob(workerssampleProbspace, isin(workerssampleProbspace, "Against"))
```

The probability of picking a worker against the regulations:

```r
workerssampleProb
```

## [1] 0.4

Probability of B given that A has occurred:

```r
workers2 <- rep(c("Against", "Favor"), times = c(7, 12))
```

Create workers of 7 against and 12 favor:

```r
workers2sample <- urnsamples(workers2, size = 1, replace = FALSE, ordered = FALSE)
```

Create a sample space of picking 1 worker where there is no replacement and the order does not matter:

```r
workers2sampleProbspace <- probspace(workers2sample)
```

Probability space of all events occurring:

```r
workers2sampleProb <- Prob(workers2sampleProbspace, isin(workers2sampleProbspace, "Against"))
```

The probability of picking a worker against the regulations:

```r
workers2sampleProb
```

## [1] 0.3684211

```r
Prob <- workerssampleProb * workers2sampleProb
```

```r
Prob
```

## [1] 0.1473684

## Compound or Joint Probability

2 points 22) Suppose that we wish to create a team of 17 people out of a class of 21 people, how many different teams are possible?

```r
n <- 21
r <- 17
```

```r
choose(n, r)
```

## [1] 5985

## or

```r
library(combinat)
col(comb(n, r))
```

## [1] 5985
2 points 23) Suppose that we wish to create a team of 17 people out of a class of 23 people so that each team is unique with regards to the order chosen, how many distinct teams are possible?

\[
n \left( \frac{\text{factorial}(n)}{\text{factorial}(n - r)} \right)
\]

\[
\text{n} \left( \frac{\text{factorial}(n)}{\text{factorial}(n - r)} \right)
\]

## [1] 3.590558e+19

[6 points total] 24) Suppose that LRB Engineers, Inc. tested the depleted uranium (DU) shell on its weapons system over the course of 27,160 hours and there were 8,524 failures during that time period.

2 points 24) a) What is the failure rate?

\[
\text{fr} = \frac{\text{tf}}{\text{th}}
\]

\[
\text{fr} = \frac{8524}{27160}
\]

## [1] 0.3138439

2 points 24) b) If the maximum failure rate for this system is 0.293 failures per hour, then is this failure rate acceptable? (Answer in complete sentences)

No, the failure rate of 0.314 failures/hour is above the maximum failure rate of 0.293 failures/hour so it is not acceptable.

2 points 24) c) If Cruft Lipshod, the company CEO, asks you to change the test data if it’s above the maximum failure rate, then what is your ethical response, as the engineer on this project? (Answer in complete sentences)

3 points 25) A person borrows A$13,247.75 (Australian dollars) at an annual interest rate of 26.13% with the entire amount due in 12 years. How much must be paid at the end of the period in US dollars?

\[
\text{I} = P \times n \times i \quad \text{## total interest using simple interest}
\]

\[
\text{SimpIntPaid} \left( \frac{1 + n \times i}{100} \right) \quad \text{## total amount paid}
\]
return(round(SimpIntPaid, digits = 2))
}

Ad <- 13247.75 ## Australian dollars
USd <- Ad * (0.7085 / 1) ## US dollars
i <- 26.13 ## % interest rate
n <- 12 ## years

SimpIntPaid(USd, n, i)

## [1] 38816.87

3 points @26) Refer to Problem 25) above, how much must be paid, in US dollars, at the end of the period if interest is compounded monthly?

CompIntPaid <- function (P, n, i) {
  i <- i / 100
  fr <- 12
  n <- n * fr
  i <- i / fr
  CompIntPaid <- P * (1 + i) ^ n ## total amount paid
  return(round(CompIntPaid, digits = 2))
}

Ad <- 13247.75 ## Australian dollars
USd <- Ad * (0.7085 / 1) ## US dollars
i <- 26.13 ## % interest rate
n <- 12 ## years

CompIntPaid(USd, n, i)

## [1] 208757.1

3 points !27) A small municipality experiences inflation of 20% per month. What is the effective annual inflation rate?

EffInt <- function (r) {
  r <- r / 100

  r <- r / 100
fr <- 12
n <- fr
r <- (fr * r)
i <- r / n
EffInt <- ((1 + i) ^ n - 1) * 100  # effective interest rate
return(round(EffInt, digits = 2))

r <- 20  # % inflation rate per month
EffInt(r)

# [1] 791.61

2 points 28) If the LRB Engineers Credit Union pays 0.9915% interest compounded quarterly, then what is the effective annual interest rate?

EffInt <- function (r) {
  r <- r / 100
  fr <- 4
  n <- fr
  r <- (fr * r)
i <- r / n
  EffInt <- ((1 + i) ^ n - 1) * 100  # effective interest rate
  return(round(EffInt, digits = 2))
}

r <- 0.9915  # % inflation rate per month
EffInt(r)

# [1] 4.03

16 points #&29) Consider the value of $1 that you might receive in 1, 10, 50, and 100 years. The relevant compound interest formula (model) given in most economics/investment texts is
\[ P = \frac{S_n}{(1 + i)^n} \]

This gives the present worth (PW) equivalent (P) of an amount \( S_n \) occurring at year \( n \), at interest/discount rate \( i \). \( 1/(1 + i)^n \) is termed the present worth factor.

Do this calculation for interest/discount rates, \( i \), of 1\%, 5\%, 10\%, and 25\% per annum (year), and years, \( n \), of 1, 10, 50, and 100.

<table>
<thead>
<tr>
<th></th>
<th>1 Year</th>
<th>10 Years</th>
<th>50 Years</th>
<th>100 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5%</td>
<td></td>
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<td>10%</td>
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</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( Sn \leftarrow 1 \) ## US dollar
\( i \leftarrow c(1, 5, 10, 25) / 100 \) ## percent per annum
\( n \leftarrow c(1, 10, 50, 100) \) ## number of years

\( Pi1 \leftarrow Sn / (1 + i[1]) ^ n \) ## P for \( i \) of 1\%
\( Pi5 \leftarrow Sn / (1 + i[2]) ^ n \) ## P for \( i \) of 5\%
\( Pi10 \leftarrow Sn / (1 + i[3]) ^ n \) ## P for \( i \) of 10\%
\( Pi25 \leftarrow Sn / (1 + i[4]) ^ n \) ## P for \( i \) of 25\%

```
library(data.table)
## data.table 1.9.6 For help type ?data.table or https://github.com/Rdatatable/data.table/wiki
## The fastest way to learn (by data.table authors): https://www.datacamp.com/courses/data-analysis
##
## Attaching package: 'data.table'
##
## The following object is masked from 'package:DescTools':
##
## %like%

## load the data.table library
P <- data.table(Pi1, Pi5, Pi10, Pi25)
## create a data.table out of those named vectors
P <- data.table(t(P))
## transpose P (switch rows to columns and vice versa)
setnames(P, 1:4, c("1 Year", "10 Years", "50 Years", "100 Years"))
## change the column names of data.table P
P <- setDF(P, rownames = c("1%", "5%", "10%", "25%"))
## create a data.frame out of the existing data.table using the given row names
P ## has scientific notation for some values
```
### 1 Year 10 Years 50 Years 100 Years
### 1% 0.9900990 0.9052870 0.6080388247 0.3697112123
### 5% 0.9523810 0.6139133 0.0872037270 0.0076044900
### 10% 0.9090909 0.3855433 0.0085185513 0.0000725657
### 25% 0.8000000 0.1073742 0.0000142725 0.0000000002

**round(P, digits = 10)** does not have scientific notation

### 1 Year 10 Years 50 Years 100 Years
### 1% 0.9900990 0.9052870 0.6080388247 0.3697112123
### 5% 0.9523810 0.6139133 0.0872037270 0.0076044900
### 10% 0.9090909 0.3855433 0.0085185513 0.0000725657
### 25% 0.8000000 0.1073742 0.0000142725 0.0000000002

9 points 30) LRB Engineers, Inc. is interested in purchasing either a new or used dump truck at 24.139% annual interest rate. Use the information in the table below to help LRB Engineers, Inc. decide which dump truck to purchase using the benefit-cost ratio discussed in Lecture 7 Notes. Which dump truck should the company purchase and why? (**Answer in complete sentences**)

<table>
<thead>
<tr>
<th></th>
<th>Used dump truck</th>
<th>New dump truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial cost</td>
<td>£100,000</td>
<td>£250,000</td>
</tr>
<tr>
<td>life</td>
<td>18 years</td>
<td>22 years</td>
</tr>
<tr>
<td>annual O&amp;M</td>
<td>£3,000</td>
<td>£45,000</td>
</tr>
<tr>
<td>annual benefits</td>
<td>£250,000</td>
<td>£220,000</td>
</tr>
<tr>
<td>salvage value</td>
<td>£25,000</td>
<td>£70,000</td>
</tr>
</tbody>
</table>

\[
\text{benefitcost} <- \text{function (ic1, n1, ac1, ab1, i1, salvage1, ic2, n2, ac2, ab2, i2, salvage2, option1, option2)}
\]

**## option 1**
**## cost 1**
\[
i1 <- i1 / 100
\]

\[
cost1 <- \text{ic1 + (ac1 * (((1 + i1)^n1 - 1) / (i1 * ((1 + i1)^n1))))}
\]

**## benefit 1**
\[
\text{benefit1} <- \text{ab1 * (((1 + i1)^n1 - 1) / (i1 * ((1 + i1)^n1)))}
\]

\[
b_c1 <- \text{benefit1} / \text{cost1}
\]

**## option 2**
**## cost 2**
\[
i2 <- i2 / 100
\]

\[
cost2 <- \text{ic2 + (ac2 * (((1 + i2)^n2 - 1) / (i2 * ((1 + i2)^n2)))) - (salvage2 * ((1 / (1 + i2)^n2)))}
\]

24
## Benefit 2

```r
benefit2 <- ab2 * (((1 + i2) ^ n2 - 1) / (i2 * ((1 + i2) ^ n2)))
```

```r
b_c2 <- benefit2 / cost2
```

## Benefit-Cost ratio of Option 2 to Option 1

```r
b_c_rank <- (benefit2 - benefit1) / (cost2 - cost1)
```

```r
b_c_rank_choose <- ifelse(b_c_rank >= 1, paste0("choose", " ", option2, "."), paste0("choose", " ", option1, "."))
```

```r
ptable <- data.frame(c(NA_character_, "Benefit", "Cost", "Benefit-Cost Ratio"), c(option1, formatC(benefit1, big.mark = ",", format = "f", digits = 2)), formatC(cost1, big.mark = ",", format = "f", digits = 2), round(b_c1, digits = 2), c(option2, formatC(benefit2, big.mark = ",", format = "f", digits = 2)), formatC(cost2, big.mark = ",", format = "f", digits = 2), round(b_c2, digits = 2)), stringsAsFactors = FALSE)
```

```r
col.names <- as.character(ptable[1,])
```

```r
colnames(ptable) <- col.names
```

```r
ptable <- ptable[-1,]
```

```r
cat("\n", paste("The Benefit-Cost ratio of ", option2, " to ", option1, " is ", round(b_c_rank, digits = 2)), " thus choose ", b_c_rank_choose), "\n")
```

## Code block below modified from data.frame function

```r
attr(ptable, "col.names") <- col.names
```

```r
attr(ptable, "class") <- "data.frame"
```

```r
ptable
```

## Using British pounds

```r
benefitcost(ic1 = 100000, n1 = 18, ac1 = 3000, ab1 = 250000, i1 = 10, salvage1 = 25000, ic2 = 250000, n2 = 22, ac2 = 45000, ab2 = 220000, i2 = 10, salvage2 = 70000, option1 = "Used dump truck", option2 = "New dump truck")
```

## The Benefit-Cost ratio of New dump truck to Used dump truck is -0.24 thus choose Used dump truck.

```r
##
## 2  Benefit 2,050,353.03 1,929,738.86
## 3  Cost 124,604.24 636,120.09
## 4 Benefit-Cost Ratio 16.45 3.03
```

## Using US dollars

```r
pound <- c(100000, 3000, 250000, 25000, 250000, 45000, 220000, 70000)
```

```r
USd <- pound * (1.5217 / 1) ## US dollars
```

```r
benefitcost(ic1 = USd[1], n1 = 18, ac1 = USd[2], ab1 = USd[3], i1 = 10, salvage1 = USd[4], ic2 = USd[5], n2 = 22, ac2 = USd[6], ab2 = USd[7], i2 = 10, salvage2 = USd[8], option1 = "Used dump truck", option2 = "New dump truck")
```

## The Benefit-Cost ratio of New dump truck to Used dump truck is -0.24 thus choose Used dump truck.

```r
##
## 2  Benefit 3,120,022.20 2,936,483.62
## 3  Cost 189,610.27 967,983.95
## 4 Benefit-Cost Ratio 16.45 3.03
```
5 points 31) Name at minimum 5 of Irucka Embry’s Grand Challenges to Engineering [http://www.ecoccs.com/grand_challenges_engineering.html]. (Answer in complete sentences)

I. We must reclaim our humanity through creatively imagining the future with everyone (every being on this planet is a stakeholder — not only our clients, employers, and local ecosystems and local human communities).

II. We must change our engineering foundations from Newtonian/Cartesian thinking (mechanical-based, disconnected, separate, reductionist analytical theories and laws) to integrative and complementary, fluid, circular, holistic living systems-based, connected, conceptual theories and laws. We can not change the world for the better until we change the way that we view the world.

III. We must choose peace and not war. We must decide to use our intelligence to create a peaceful, fair, just, and humane world. We have participated way too long in Wars where we systematically kill ourselves, therefore we must begin the process of healing and saving ourselves. We must support and engage in research efforts that enhance everyone’s humanity, imagination, creativity, and overall well-being.

IV. We must support ethics by not condoning corruption and other unethical behaviors in our business dealings, pursuits, research, etc.

V. We must examine our design and construction processes through life cycle ecological & temporal synthesis (geologic time constraints, internal and external costs, ecosystem health impact, human health impact, overall global impacts — biogeophysicochemical cycles, etc.) rather than life cycle analysis.

VI. We must develop frameworks similar to the Cradle to Cradle framework created by the MBDC.

VII. We must develop energy effective rather than energy efficient products (source: McDonough Braungart Design Chemistry (MBDC)).

VIII. We must work with the general public better because solving the world’s problems and avoiding creating future problems requires working in true interdisciplinary teams.

IX. We must continue research efforts in the field of biomimicry. (source: Schauberger & Biomimicry 3.8)

X. We must uphold ecological health systems [ecosystem health & human health (biological, economic, emotional, social, spiritual) in our top lines rather than our bottom lines (source for triple top lines: McDonough Braungart Design Chemistry (MBDC)).
Extra Credit

For each extra credit problem, you can either solve the problem using R or MATLAB(R)/GNU Octave (no Microsoft Excel)

10 points extra credit #1) An amount of money P is invested in an account where interest is compounded at the end of the period. The future worth F yielded at an interest rate i after n periods may be determined from the following formula:

$$ F = P \times (1 + i)^n $$

Write a function that will calculate the future worth of an investment for each year from 1 through n. The input to the function should include the initial investment P, the interest rate i (as a decimal), and the number of years n for which the future worth is to be calculated. The output should consist of a table with headings and columns for n and F. Run the program for P = £285,940.45 (British pound), i = 7.1284%, and n = 17 years. Provide the table in US dollars.

```r
library(data.table)
F <- function (P, n, i) {
  i <- i / 100

  fr <- 1
  n <- n * fr
  i <- i / fr

  F <- vector("list", length(1:n))
  ## Source 1 and 2 / pre-allocate the list since it is being used in a for loop
  for (y in 1:length(n)) {
    F[y] <- P * ((1 + i) ^ seq(n))
  }
  F <- data.table(seq(n), unlist(F))
  setnames(F, c("n (years)", "Future Worth ($US)"))
  F <- setDF(F)
  return(F)
}

pound <- 285940.45 ## British pounds
USd <- pound * (1.5217 / 1) ## US dollars
i <- 7.1284 ## % interest rate
n <- 17 ## years

F(USd, n, i)
```

## n (years) Future Worth ($US)
## 1 1 466132.4
Economic formulas are available to compute annual payments for loans. Suppose that you borrow an amount of money \( P \) and agree to repay it in \( n \) annual payments at an interest rate of \( i \). The formula to compute the annual payment \( A \) is

\[
A = P \times \frac{i (1 + i)^n}{(1 + i)^n - 1}
\]

Write a function to compute \( A \). Test it with \( P = \$759,214.68 \) (Canadian dollars) and an interest rate of 6.216\%. Compute results for \( n = 1:20 \) and display the results as a table with headings and columns for \( n \) and \( A \). Provide the table in US dollars.
A <- data.table(seq(n), A)
setnames(A, c("n (years)", "Annual Payment ($US)"))
A <- setDF(A)
A

## n (years) Annual Payment ($US)
## 1  1        604241.11
## 2  2        311227.42
## 3  3        213674.48
## 4  4        164986.57
## 5  5        135844.49
## 6  6        116475.13
## 7  7        102689.98
## 8  8        92394.76
## 9  9        84425.95
##10 10       78085.42
##11 11       72928.86
##12 12       68660.08
##13 13       65073.98
##14 14       62024.06
##15 15       59402.87
##16 16       57129.81
##17 17       55143.24
##18 18       53395.18
##19 19       51847.78
##20 20       50470.73

*! The following currency conversions apply to Problems 3 – 6:
$1 = 5.045 francs (Fr)
1 yen (Y) = $0.0101239
1.4682 deutsche mark (DM) = $1
5 points extra credit *!3) Generate a table of conversions from francs to dollars. Start the francs column at 1 Fr and increment by 1 Fr. Print 100 lines in the table.

library(data.table)

Fr <- 5.045  ## francs (Fr)
Frseq <- seq(100)
USd <- Frseq * (1 / Fr)  ## US dollars
table1 <- data.table(Frseq, USd)
setnames(table1, c("francs (Fr)", "$(US dollars)"))
table1
<table>
<thead>
<tr>
<th>francs (Fr)</th>
<th>US dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1982161</td>
</tr>
<tr>
<td>2</td>
<td>0.3964321</td>
</tr>
<tr>
<td>3</td>
<td>0.5946482</td>
</tr>
<tr>
<td>4</td>
<td>0.7928642</td>
</tr>
<tr>
<td>5</td>
<td>0.9910803</td>
</tr>
<tr>
<td>6</td>
<td>1.1892963</td>
</tr>
<tr>
<td>7</td>
<td>1.3875124</td>
</tr>
<tr>
<td>8</td>
<td>1.5857284</td>
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<tr>
<td>9</td>
<td>1.7839445</td>
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<tr>
<td>10</td>
<td>1.9821606</td>
</tr>
<tr>
<td>11</td>
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<tr>
<td>12</td>
<td>2.3785927</td>
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<tr>
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<td>2.5768087</td>
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<td>14</td>
<td>2.7750248</td>
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</tbody>
</table>
5 points extra credit

4) Generate a table of conversions from deutsche marks to francs. Start the deutsche marks column at 1 DM and increment by 1 DM. Print 100 lines in the table.

```r
library(data.table)

Fr <- 5.045 # francs (Fr)
DM <- 1.4682 # deutsche marks (DM)
DMseq <- seq(100)

Fr2 <- DMseq * (1 / DM) * (Fr / 1) # deutsche marks (DM)

table2 <- data.table(DMseq, Fr2)
setnames(table2, c("deutsche marks (DM)", "francs (Fr)"))

## deutsche marks (DM) francs (Fr)
## 1: 1 3.436180
## 2: 2 6.872361
## 3: 3 10.308541
## 4: 4 13.744721
## 5: 5 17.180902
## 6: 6 20.617082
## 7: 7 24.053262
## 8: 8 27.489443
## 9: 9 30.925623
## 10: 10 34.361804
## 11: 11 37.797984
## 12: 12 41.234164
## 13: 13 44.670345
## 14: 14 48.106525
## 15: 15 51.542705
## 16: 16 54.978886
## 17: 17 58.415066
## 18: 18 61.851246
## 19: 19 65.287427
## 20: 20 68.723607
## 21: 21 72.159787
## 22: 22 75.595968
## 23: 23 79.032148
## 24: 24 82.468329
## 25: 25 85.904509
## 26: 26 89.340689
## 27: 27 92.776870
## 28: 28 96.213050
## 29: 29 99.649230
## 30: 30 103.085411
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<td>79</td>
<td>271.458248</td>
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<tr>
<td>80</td>
<td>274.894429</td>
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</tbody>
</table>
5 points extra credit *

5) Generate a table of conversions from yen to deutsche marks. Start the yen column at 1 Y, and print 100 lines.

```r
library(data.table)

USD <- 0.0101239 # US dollars
DM <- 1.4682 # deutsche marks (DM)
Yseq <- seq(100)

DM2 <- Yseq * (USD / 1) * (DM / 1) # deutsche marks (yen)
table3 <- data.table(Yseq, DM2)
setnames(table3, c("yen (Y)", "deutsche marks (DM)"))
table3
```

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<th>yen (Y)</th>
<th>deutsche marks (DM)</th>
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</thead>
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<td>y</td>
<td>z</td>
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</tbody>
</table>
5 points extra credit *6) Generate a table of conversions from dollars to francs, deutsche marks, and yen. Start the column with $1, and increment by $1. Print 100 lines in the table.

```r
library(data.table)

USd <- 0.0101239 ## US dollars
DM <- 1.4682 ## deutsche marks (DM)
USdseq <- seq(100)
```
```r
US2fr <- USdseq * (Fr / 1)
US2DM <- USdseq * (DM / 1)
US2Y <- USdseq * (1 / USd)

setnames(table4, c("$ (US dollars)", "francs (Fr)", "deutsche marks (DM)", "yen (Y)"))
table4
```

<table>
<thead>
<tr>
<th></th>
<th>$ (US dollars)</th>
<th>francs (Fr)</th>
<th>deutsche marks (DM)</th>
<th>yen (Y)</th>
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<td>2077.97094</td>
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<td>110.1591</td>
<td>4677.97094</td>
</tr>
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<td>39</td>
<td>196.755</td>
<td>113.2711</td>
<td>4777.97094</td>
</tr>
<tr>
<td>40:</td>
<td>40</td>
<td>201.800</td>
<td>116.3831</td>
<td>4877.97094</td>
</tr>
</tbody>
</table>
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## 41: 41 206.845 60.1962 4049.82270
## 42: 42 211.890 61.6644 4148.59886
## 43: 43 216.935 63.1326 4247.37502
## 44: 44 221.980 64.6008 4346.15119
## 45: 45 227.025 66.0690 4444.92735
## 46: 46 232.070 67.5372 4543.70351
## 47: 47 237.115 69.0054 4642.47968
## 48: 48 242.160 70.4736 4741.25584
## 49: 49 247.205 71.9418 4840.03200
## 50: 50 252.250 73.4100 4938.80817
## 51: 51 257.295 74.8782 5037.58433
## 52: 52 262.340 76.3464 5136.36049
## 53: 53 267.385 77.8146 5235.13666
## 54: 54 272.430 79.2828 5333.91282
## 55: 55 277.475 80.7510 5432.68898
## 56: 56 282.520 82.2192 5531.46515
## 57: 57 287.565 83.6874 5630.24131
## 58: 58 292.610 85.1556 5729.01747
## 59: 59 297.655 86.6238 5827.79364
## 60: 60 302.700 88.0920 5926.56980
## 61: 61 307.745 89.5602 6025.34596
## 62: 62 312.790 91.0284 6124.12213
## 63: 63 317.835 92.4966 6222.89829
## 64: 64 322.880 93.9648 6321.67445
## 65: 65 327.925 95.4330 6420.45062
## 66: 66 332.970 96.9012 6519.22678
## 67: 67 338.015 98.3694 6618.00294
## 68: 68 343.060 99.8376 6716.77911
## 69: 69 348.105 101.3058 6815.55527
## 70: 70 353.150 102.7740 6914.33143
## 71: 71 358.195 104.2422 7013.10760
## 72: 72 363.240 105.7104 7111.88376
## 73: 73 368.285 107.1786 7210.65992
## 74: 74 373.330 108.6468 7309.43609
## 75: 75 378.375 110.1150 7408.21225
## 76: 76 383.420 111.5832 7506.98841
## 77: 77 388.465 113.0514 7605.76458
## 78: 78 393.510 114.5196 7704.54074
## 79: 79 398.555 115.9878 7803.31690
## 80: 80 403.600 117.4560 7902.09307
## 81: 81 408.645 118.9242 8000.86923
## 82: 82 413.690 120.3924 8099.64539
## 83: 83 418.735 121.8606 8198.42156
## 84: 84 423.780 123.3288 8297.19772
## 85: 85 428.825 124.7970 8395.97388
## 86: 86 433.870 126.2652 8494.75005
## 87: 87 438.915 127.7334 8593.52621
## 88: 88 443.960 129.2016 8692.30237
## 89: 89 449.005 130.6698 8791.07854
## 90: 90 454.050 132.1380 8889.85470
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### 92: 92 464.140 135.0744 9087.40703
### 93: 93 469.185 136.5426 9186.18319
### 94: 94 474.230 138.0108 9284.95935
### 95: 95 479.275 139.4790 9383.73552
### 96: 96 484.320 140.9472 9482.51168
### 97: 97 489.365 142.4154 9581.28784
### 98: 98 494.410 143.8836 9680.06401
### 99: 99 499.455 145.3518 9778.84017
### 100: 100 504.500 146.8200 9877.61633

$ (US dollars) francs (Fr) deutsche marks (DM) yen (Y)$

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Source 1: r - Add a Column to a Dataframe From a List of Values - Stack Overflow ([http://stackoverflow.com/questions/11130037/add-a-column-to-a-dataframe-from-a-list-of-values/11130178](http://stackoverflow.com/questions/11130037/add-a-column-to-a-dataframe-from-a-list-of-values/11130178)). Answer by Matthew Plourde on Jun 21 2012


Mechanical Engineering at the University of Delaware, Senior Design 2006 Resources, Team Norms and Communication, <http://www.me.udel.edu/old-meeg401/06/teams-norms-comm.pdf>.


