

Lecture 7: Introduction to Engineering Economics

Irucka Embry, EIT

Fall 2015

Freshman Engineering Seminar ENGR 1020

Tennessee State University College of
Engineering

Department of Civil & Architectural Engineering

Outline

- Uniform Commercial Code (UCC)
- Economics
- Introduction to Engineering Economics
- FE Reference Handbook
- Works Cited

Uniform Commercial Code (UCC)

- Cornell University Law School Legal Information Institute (LII): Uniform Commercial Code: <https://www.law.cornell.edu/ucc>
- USLegal, Inc.: Uniform Commercial Code: <http://uniformcommercialcode.uslegal.com/>
- Uniform Commercial Code: https://en.wikipedia.org/wiki/Uniform_Commercial_Code
: From Wikipedia, the free encyclopedia

Economics 1

- What is money?
- What is currency?
- What is economics?
- What is engineering economics?

Economics 2

- What is money?
 - “Money is any object or record that is generally accepted as payment for goods and services and repayment of debts in a given socio-economic context or country. The main functions of money are distinguished as: a medium of exchange; a unit of account; a store of value; and, occasionally in the past, a standard of deferred payment. Any kind of object or secure verifiable record that fulfills these functions can be considered money.” (Wikipedia Money)
 - “We’ve pointed out for 4 1/2 years that **banks create money out of thin air**. Specifically, it has now been conclusively proven that loans come first ... and then deposits FOLLOW. This is the most important secret about modern banking ... because it debunks one of the biggest myths preventing a strong economy, challenges one of the main pork barrel profit centers for big banks ... and opens up incredible opportunities for a prosperous economy.” (Washington’s Blog)
- What is currency?
 - “A currency in the most specific use of the word refers to money in any form when in actual use or circulation, as a medium of exchange, especially circulating paper money. This use is synonymous with banknotes, or (sometimes) with banknotes plus coins, meaning the physical tokens used for money by a government.” (Wikipedia Currency)

Economics 3

- What is economics?
 - “Economics is the social science that analyzes the production, distribution, and consumption of goods and services.” (Wikipedia Economics)
- What is engineering economics?
 - “Engineering economics, previously known as engineering economy, is a subset of economics for application to engineering projects. Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects.” (Wikipedia Engineering Economics)

Engineering Economics

- Interest and Compounding Periods
- Effective Interest Rate
- Simple Interest
- Compound Interest
- Future Worth
- Present Value
- Benefit-Cost Analysis
- Source for text and equations is NCEES, unless otherwise stated.

Interest and Compounding Periods

- Interest (Sullivan 163)
 - Nominal – the interest rate per interest period (ex. 12% compounded semiannually)
 - Effective – the actual (or effective) annual rate on the principal (ex. 25.44% is the actual interest for the 12% compounded semiannually)
- Interest (Onwubiko 205, 206)
 - Simple – If the interest charged is applied to the principal amount borrowed.
 - Compound – If the interest charged is based not only on the original principal, but on the interest due but not yet paid.
- Compounding periods and the number of interest periods in a year in parentheses (Sullivan 164)
 - Annual (1)
 - Semiannual (2)
 - Quarter (4)
 - Bimonth (6)
 - Month (12)
 - Daily (365)

Effective Interest Example

1 (Lindeburg)

- If a credit union pays 4.125% interest compounded quarterly, what is the effective annual interest rate?

Effective Interest Example

2 (Lindeburg)

- Solution:
- the effective interest rate per period, as a decimal number, i , is $\frac{r}{m}$
- r is the nominal interest rate (rate per annum), as a decimal number
- m is the compounding period (daily, semiannually, quarterly, annually, etc.)
- The effective annual interest rate, i_e , is

$$i = \frac{r}{m} \quad i_e = (1+i)^m - 1 \quad i_e = \left(1 + \frac{r}{m}\right)^m - 1$$

Effective Interest Example

3 (Lindeburg)

- Solution:
- $r = 4.125\% = 0.04125$ (nominal interest rate)
- $m = 4$ (quarterly)

$$i_e = \left(1 + \frac{r \times m}{m}\right)^m - 1$$

$$i_e = \left(1 + \frac{0.04125 \times 4}{4}\right)^4 - 1 = 0.1755$$

- $i_e = 17.55\%$ (effective annual interest rate)

Effective Interest Example

4

- Find the effective annual interest rate using R
- Solution:

```
source("EffInt.R")
```

```
EffInt(4.125, frequency = "quarter") # the  
nominal interest rate per period (quarter)  
is 4.125%
```

```
[1] 17.55 # %
```

Simple Interest (Sullivan 116), (Onwubiko 206)

- When simple interest is applicable, the total interest, I , earned or paid can be found using the formula:

$$I = (P)(N)(i)$$

Where P = principal amount lent or borrowed

N = number of interest periods (e.g., years)

i = interest rate per interest period

The total amount repaid at the end of N interest periods is

$$S_n = P + I$$

or

$$S_n = P(1 + ni)$$

Simple Interest Example 1

(Sullivan 116), (Onwubiko 206)

- If \$1,000 were loaned for three years at a simple interest rate of 10% per year, what is the total amount to be repaid?

$$I = (P)(N)(i)$$

$$I = (1000)(3)(0.10) = \$300 \text{ (total interest paid)}$$

$$S_n = P + I = 1000 + 300 = \$1300 \text{ (total amount repaid)}$$

or

$$S_n = P(1 + 3 * 0.10) = \$1300 \text{ (total amount repaid)}$$

Simple Interest Example 2

- Find the total amount paid with simple interest using R
- Solution:

```
source("SimplIntPaid.R")
```

```
SimplIntPaid(1000, 3, 10) # the interest rate is  
10%
```

```
[1] 1300 # US dollars
```

Compound Interest (Sullivan 117), (Onwubiko 206)

- Whenever the interest charge for any interest period (ex., a year) is based on the remaining principal amount plus any accumulated interest charges up to the beginning of that period, the interest is said to be compound.

$$S_n = P(1+i)^n$$

- The formula above gives the total amount repaid with compound interest.

Compound Interest Ex. 1

(Sullivan 117), (Onwubiko 206)

- If \$1,000 were loaned for three years at a compound interest rate of 10% per year, what is the total amount to be repaid?

$$S_n = P(1+i)^n$$

- $S_n = 1000 * (1 + 0.10)^3$
- $S_n = \$1,331$

Compound Interest Example 2

- Find the total amount paid with compound interest using R
- Solution:

```
source("CompIntPaid.R")
```

```
CompIntPaid(1000, 3, 10, frequency =  
"annual") # the interest rate is 10%
```

```
[1] 1331 # US dollars
```

Future Worth given Present Value Example 1 (Lindeburg)

- If you invest A\$25,000 (Australian dollars) at 8% interest compounded once annually, approximately how much money will be in the account at the end of 10 years? This is the future worth of a present value.

Future Worth given Present Value Example 1 (Lindeburg)

- Solution:
- Convert A\$25,000 to US dollar amount

$$(A \$ 25,000) \times \left(\frac{US \$ 0.7085}{A \$ 1} \right) = US \$ 17,712.50$$

- The future worth of US\$17,712.50 from present uses the following formula for a single payment compound amount:

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

- $i = 8\% = 0.08$, $n = 10$ years, $P = US\$17,712.50$

$$F = US \$ 17,712.50 \times (1+0.08)^{10} = \$ 38,239.96$$

Future Worth given Present Value Example 1

- Find the future worth using R
- Solution:

```
source("FgivenP.R")
```

```
Ad <- 25000 # Australian dollars
```

```
USd <- Ad * (0.7085 / 1) # US dollars
```

```
FgivenP(P = USd, n = 10, i = 8, frequency = "annual") # I = 8%, n = 10 years
```

```
[1] 38239.96 # US dollars
```

Present Value given Future Worth Example 1

- You now know the Future worth of the Present value. In order to check our results, find the present worth using R.
- Solution:

```
source("PgivenF.R")
```

```
PgivenF(F = 38239.96, n = 10, i = 8, frequency = "annual")
```

```
[1] 17712.5 # US dollars
```

Note: This value calculated here should match the present value in the previous example. Does it?

Future Worth given Present Value Example 2 (Lindeburg)

- A deposit of \$1000 is made in a bank account that pays 24% interest per year compounded quarterly. Approximately how much money will be in the account after 10 years? This is the future worth given a present value.

Future Worth given Present Value Example 2 (Lindeburg)

- Solution:
- $r = 24\%$ (nominal interest rate per year)
- $i = r/m = 24\%/4 = 6\%$ (effective interest rate per quarter)

$$n = (10 \text{ years}) \left(\frac{4 \text{ quarters}}{\text{year}} \right) = 40 \text{ quarters}$$

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

$$F = \$1000 \times (1+0.06)^{40} = \$10,285.72$$

Future Worth given Present Value Example 2

- Find the future worth using R
- Solution:

```
source("FgivenP.R")
```

```
FgivenP(P = 1000, n = 10, i = 24, frequency = "quarter") # I = 24%  
nominal interest rate, n = 10 years
```

```
[1] 10285.72
```

```
FgivenP(P = 1000, n = 40, i = 6, frequency = "annual") # I = 6%  
effective interest rate, n = 40 quarters
```

```
[1] 10285.72
```

Benefit-Cost Ratio 1 (Lindeburg)

- Going Broke County is using a 10% annual interest rate to decide if it should buy snowplow A or snowplow B.

	snowplow A	snowplow B
initial cost	\$300,000	\$400,000
life	10 years	10 years
annual operations and maintenance (O & M)	\$45,000	\$35,000
annual benefits	\$150,000	\$200,000
salvage value	\$0	\$10,000

Benefit-Cost Ratio 2 (Lindeburg)

- What are the benefit-cost ratios for snowplows A and B, respectively, and which snowplow should Going Broke County buy?

Benefit-Cost Ratio 3 (Lindeburg)

- Solution:
- The benefit-cost method requires the cash flows to be converted to present worth
- The uniform series present worth is given by this formula $\frac{(1+i)^n - 1}{i(1+i)^n}$

- For snowplow A

$$Cost(C) = \$300,000 + \$45,000 \times \left(\frac{(1+0.10)^{10} - 1}{0.10 \times (1+0.10)^{10}} \right)$$

$$Cost(C) = \$576,505.52$$

Benefit-Cost Ratio 4 (Lindeburg)

- For snowplow A

$$\text{Benefits}(B) = \$150,000 \times \left(\frac{(1+0.10)^{10} - 1}{0.10 \times (1+0.10)^{10}} \right)$$

$$\text{Benefits}(B) = \$921,685.07$$

$$\frac{B}{C} = \frac{\$921,685.07}{\$576,505.52} = 1.60$$

Benefit-Cost Ratio 5 (Lindeburg)

- For snowplow B
- The salvage value must be subtracted from the cost. Salvage value is a single payment present worth using this formula $(1+i)^{-n}$

$$Cost(C) = \$400,000 + \$35,000 \times \left(\frac{(1+0.10)^{10} - 1}{0.10 \times (1+0.10)^{10}} \right) - \$10,000 \times (1+0.10)^{-10}$$

$$Cost(C) = \$611,204.42$$

Benefit-Cost Ratio 6 (Lindeburg)

- For snowplow B

$$\text{Benefits}(B) = \$200,000 \times \left(\frac{(1+0.10)^{10} - 1}{0.10 \times (1+0.10)^{10}} \right)$$

$$\text{Benefits}(B) = \$1,228,913.42$$

$$\frac{B}{C} = \frac{\$1,228,913.42}{\$611,204.42} = 2.01$$

Benefit-Cost Ratio 7 (Lindeburg)

- To rank the projects using the benefit-cost ratio method, use an incremental analysis
- $\frac{B_2 - B_1}{C_2 - C_1} \geq 1$ For deciding to choose alternative 2

$$\frac{\$1,228,913.42 - \$921,685.07}{\$611,204.42 - \$576,505.52} = 8.85 \geq 1$$

- They should choose snowplow B

Benefit-Cost Ratio 8

- Find the future worth using R
- Solution:

```
source("benefitcost.R")
```

```
benefitcost(ic1 = 300000, n1 = 10, ac1 = 45000, ab1 = 150000, i1  
= 10, salvage1 = 0, ic2 = 400000, n2 = 10, ac2 = 35000, ab2 =  
200000, i2 = 10, salvage2 = 10000, option1 = "Snowplow A",  
option2 = "Snowplow B")
```

	Snowplow A	Snowplow B
Benefit	921,685.07	1,228,913.42
Cost	576,505.52	611,204.42
Benefit-Cost Ratio	1.6	2.01

Benefit-Cost Ratio 9

- The Benefit-Cost ratio of Snowplow B to Snowplow A is 8.85 thus choose Snowplow B.

FE Handbook

Reviewing the following pages from the *Fundamentals of Engineering Reference Handbook* (posted online at <http://www.ecoccs.com/tsuteach.html#engr1020>) will be helpful for the remainder of this semester

- iii – 17,
- 19 – 24,
- 28 – 29,
- 40 – 48,
- 109, and
- 114 – 120

Works Cited 1

- Lindeburg, PE, M. R., *EIT Review Manual*, Belmont, California: Professional Publications, Inc., 1996, p. 21-1 – 21-3, 21-5, 21-8.
- NCEES (the National Council of Examiners for Engineering and Surveying), *Fundamentals of Engineering (FE) Supplied-Reference Handbook*, 8th edition, 2nd revision, Clemson, SC: NCEES, 2011, p. 40 – 42.
- Onwubiko, C., *An Introduction to Engineering*, 1st ed., Mission, Kansas: Schroff Development Corporation, 1997, p. 205-206.
- Sullivan, William G., Wicks, Elin M., and Koelling, C. Patrick, *Engineering Economy*, Fourteenth Edition, Upper Saddle River, New Jersey: Pearson/Prentice Hall, 2009, page 116, 117, 163, 164.
- Washington's Blog. Global Research. April 28, 2014. "The Biggest Secret About Banking Has Just Gone Mainstream: Banks Create Money Out of Thin Air ... Conferring Enormous Windfall Profits At the Expense of the People" < <http://www.globalresearch.ca/the-biggest-secret-about-banking-has-just-gone-mainstream/5379509> >, Accessed: 2 November 2015.

Works Cited 2

- Wikimedia Foundation, Inc. Wikipedia, 28 October 2013, “Australian dollar”, <https://en.wikipedia.org/wiki/Australian_dollar >, Accessed: 11 November 2013.
- Wikimedia Foundation, Inc. Wikipedia, 8 November 2013, “Currency”, <<http://en.wikipedia.org/wiki/Currency> >, Accessed: 11 November 2013.
- Wikimedia Foundation, Inc. Wikipedia, 11 November 2013, “Economics”, <<http://en.wikipedia.org/wiki/Economics> >, Accessed: 11 November 2013.
- Wikimedia Foundation, Inc. Wikipedia, 23 October 2013, “Engineering economics”, <http://en.wikipedia.org/wiki/Engineering_economics >, Accessed: 11 November 2013.
- Wikimedia Foundation, Inc. Wikipedia, 11 November 2013, “Money”, <<http://en.wikipedia.org/wiki/Money> >, Accessed: 11 November 2013.
- Yahoo! Inc. Yahoo! Finance, Mon, Nov 16, 2015, 12:28 PM EST, “Currency Converter”, <<http://finance.yahoo.com/currencyconverter/#from=AUD;to=USD;amt=1> >, Accessed: Mon, Nov 16, 2015, 12:28 PM EST.