

EM384: Analytical Methods for Engineering Management

Lesson 1: Introduction and Ethics

11 January 2023

Table of contents

1. Course Overview

2. Analytics

3. Models

4. Ethics

5. Conclusion

Course Overview

Course Overview (1/3)

- My primary method of correspondence is through MS Teams.
 - Chat function to ask specific homework questions if AI is not needed.
 - Teams meeting scheduler for in-person AI (I prefer in-person), can accommodate virtual as needed.
 - EM384 [Section Teams page](#) for class discussions, and section-specific homework turn-in.
- The backup method of correspondence is email.
- For Code White / Code Red days we will most likely be holding virtual class - I will send you a link when the call is made (usually the morning of).

Course Overview (2/3)

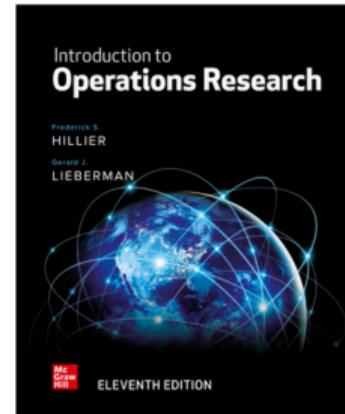
- We mark attendance as we see it.
- If you are going to miss class, be late, or depart early, let me know in advance if possible.
- No food, tobacco or drinks (except approved containers).
- Leave hats, jackets and bags in the hall.
- Don't disrupt the class.
- You don't need to ask to use the restrooms, but do so without disruption.
- **New section marcher policy.**
- Character and Honorable Living.
- No cell phones or smart watches during graded events.
- **Documentation! Always document if you receive help from anyone other than your instructor. Be careful with Excel sharing.**

Course Overview (3/3)

- Be courteous, watch your language.
- Focus on EM384 in class. If you're tired, stand up.
- Ask questions.
- Bring your computer (and mouse recommended).
- Laptops closed if not working in class.
- No emails, browsing the internet, etc., during class.
- NO Phones in class except for Kahoot or to verify Office365.
- Own your grade.
- Call out my mistakes.
- Be motivated and have fun!

Course Book

- Our course text is *Introduction to Operations Research* by Hillier, 11th Edition.
- e-Book or hard copy. If you use an e-book or PDF book, make sure it is legally purchased.
- Misuse of an e-Book is a violation of the honor code (Sharing passwords, sharing PDF, misuse of e-Book license etc.



Introduction to Operations
Research
11th Edition

By Frederick Hillier and Gerald Lieberman
ISBN10: 1259872998
ISBN13: 9781259872990

Figure 1: Course Textbook

Other Course Information

- Instructional Memorandum.
- DSE Policy Memos.
- Software: Microsoft Excel, Excel Solver add-in, Python.
- The course is challenging but doable. Do not fall behind.
- Seek AI if you need any assistance.

Graded Events

- **Graded Events:**
 - WPR: (3 x 150): **450 points**
 - Homework Sets: (10 x 20): **200 points**
 - Course Quizzes (3 x 20): **60 Points**
 - Instructor Points: Quizzes/Other Homework **40 points**
 - TEE: **250 points**
- **Minimum Requirements:** Complete the course with at least 65% and the TEE with at least 50%.
- **Missing Events:** Cadets who will miss an event must contact the instructor as soon they know about the conflict. It is the cadet's responsibility to coordinate with the instructor to make up any material/requirements BEFORE they are missed.
- **Late Submissions:** Failure to attend or submit a graded event on time for other than legitimate, compelling reasons will result in a reduced grade (-5% of max points per 24-hour period) and may result in disciplinary action.

Course Overview

1. Modeling and Spreadsheet Engineering

- Excel Skills
- Spreadsheet Modeling
- Data Analysis



Modeling



Monte Carlo Simulation

4. Monte Carlo Simulation

- Distributions
- Corporate Valuation



Transportation Flow

2. Optimization Models

- Linear Programming
- Allocation & Cost-Benefit Trade-off
- Mixed Problems
- Fixed-Requirements



Portfolio Optimization

3. Network and Integer Programming Models

- Network Flow
- Transportation
- Assignment
- Transshipment
- Binary Integer Programming
- Nonlinear Programming

Cadets are asked to: 1) analyze decision opportunities and recognize their key components using appropriate technology and engineering management tools and 2) identify problems, build, and analyze models to identify the best alternative.

The Systems Decision Process

The **systems decisions process** (SDP) leverages multiple objective decision analysis, multiple attribute value theory, and value-focused thinking to define the problem, measure stakeholder value, design creative solutions, explore the decision trade off space in the presence of uncertainty, and structure successful solution implementation.¹

¹Decision Making in Systems Engineering and Management, Second Edition

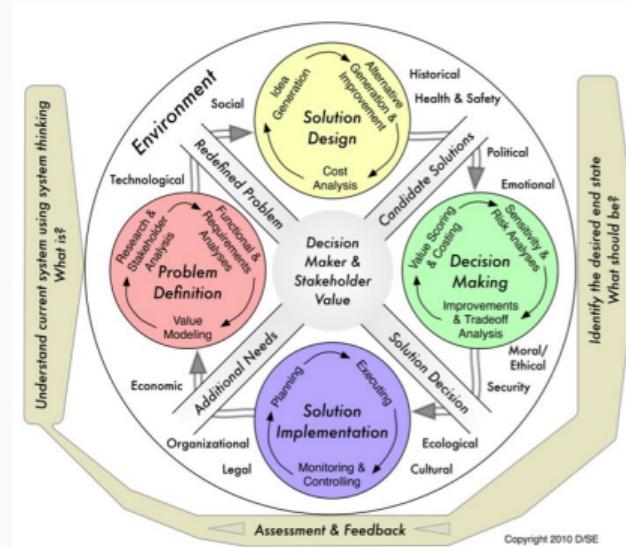
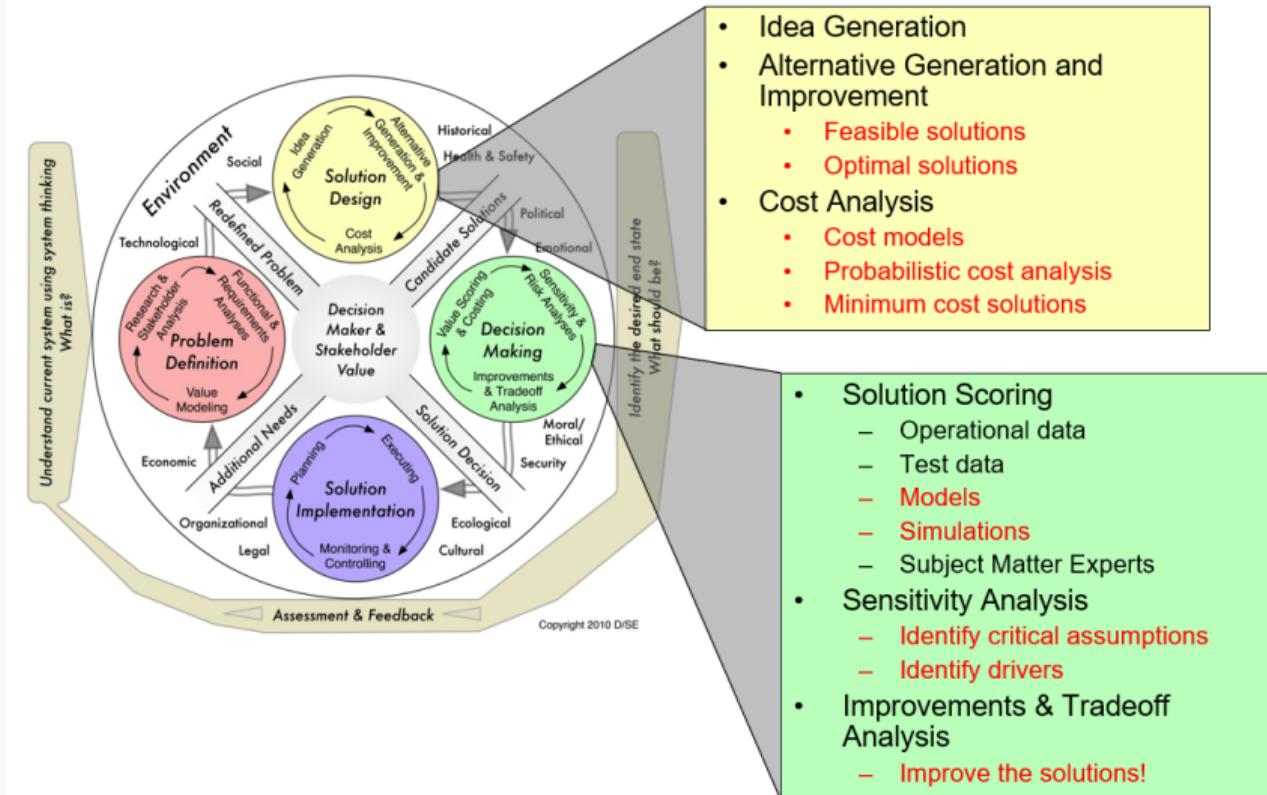
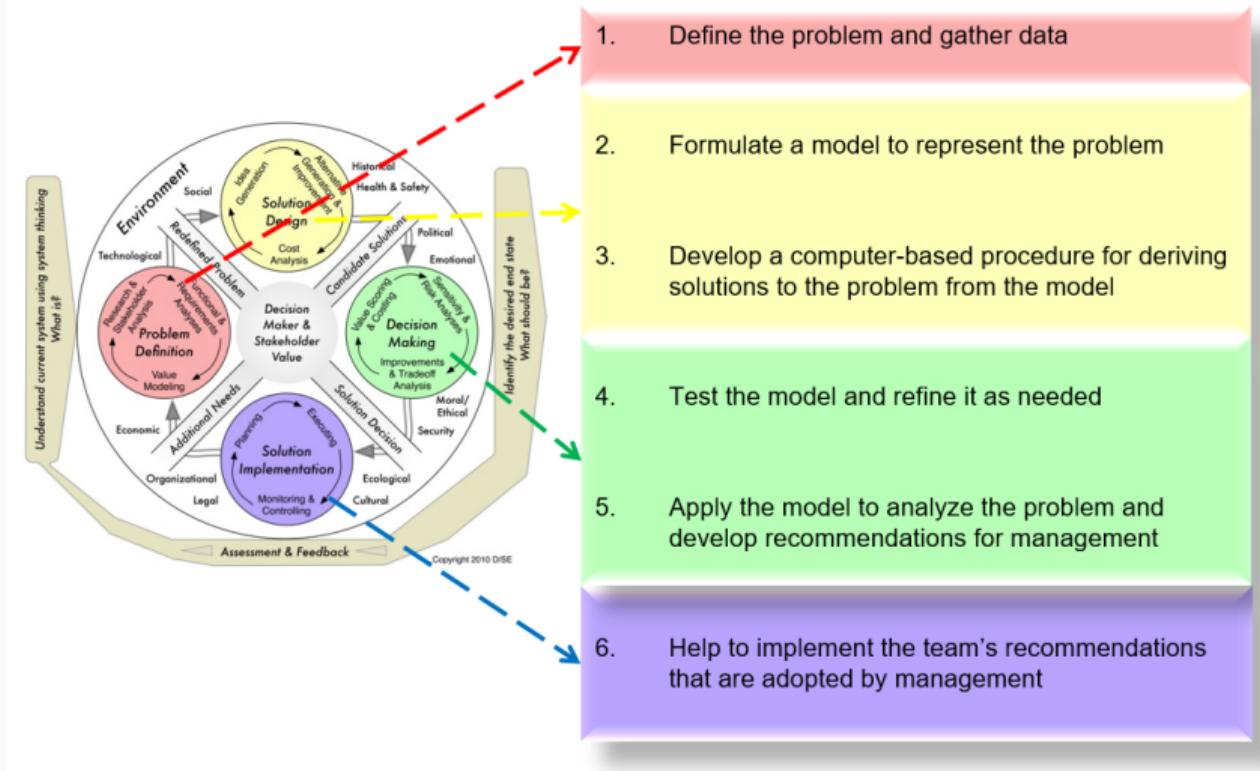


Figure 2: Systems Decision Process

Analytical Methods in the SDP



Hillier's Approach and the SDP



Lesson 1 Objectives

- Define a model and describe the different forms of models (Physical, Graphical, Mathematical).
- Understand the difference between the three types of analytics (Descriptive, Predictive, prescriptive).
- Recognize the ethical considerations involved with gathering and analyzing data, using quantitative models, validating assumptions, and reporting results.

Analytics

Management Science is often synonymous with Operations Research.

- It is a discipline that attempts to aid managerial decision making by applying a scientific approach to managerial problems that involve quantitative factors.
- It is supported by Analytics, or Business Analytics.

Descriptive Analytics

The use of data to analyze trends

Predictive Analytics

The use of data to forecast what will happen in the future

Prescriptive Analytics

The use of data to prescribe the best course of action

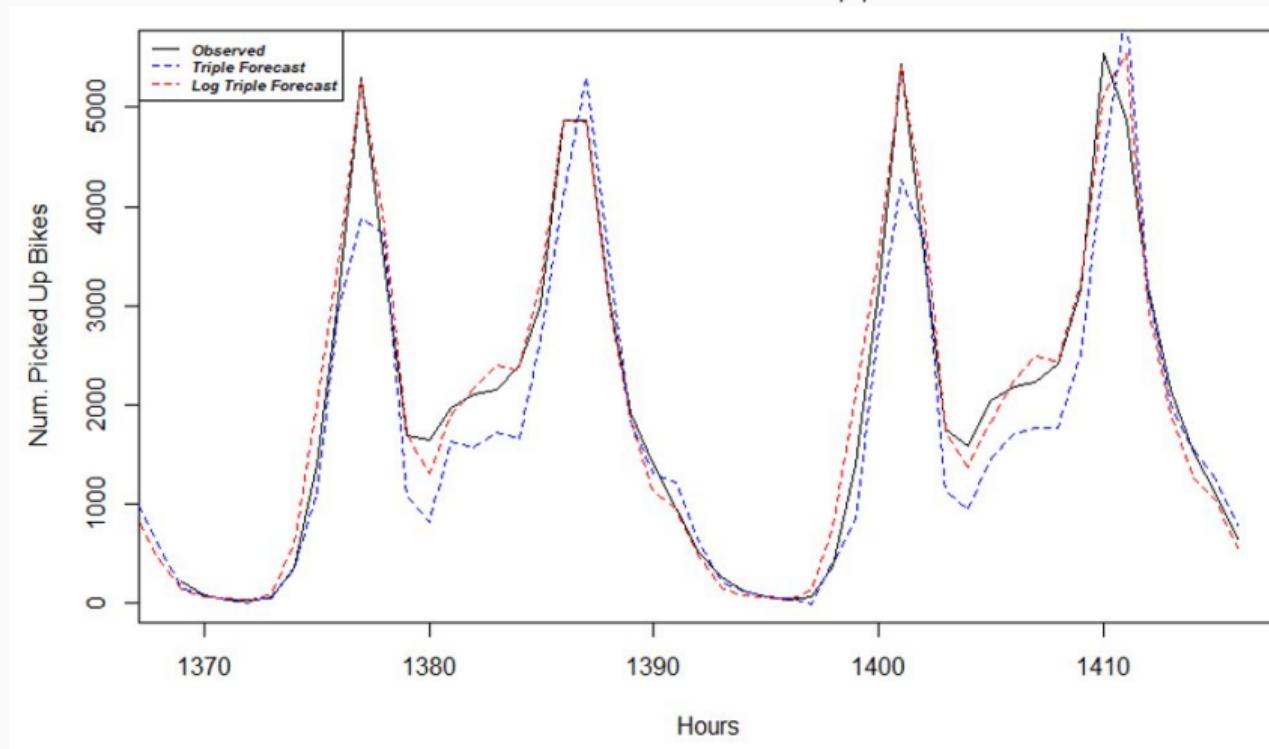
Descriptive Analytics

"The use of data to analyze trends"

Tm	#Bat	BatAge	R/G	G	PA	AB	R	H	2B	3B	HR	RBI	SB	CS	BB	SO	BA	OBP	SLG	OPS	OPS+	TB	GDP	HBP	SH	SF	IBB	LOB
BAL	53	26.6	4.38	120	4548	4130	526	1012	186	21	154	500	61	24	329	1096	.245	.306	.412	.718	.89	1702	75	46	17	26	6	780
BOS	44	27.2	5.72	123	4928	4392	704	1207	269	20	190	670	56	21	454	1038	.275	.345	.475	.820	.109	2086	96	36	12	32	29	901
CHW	46	27.7	4.10	118	4383	4014	484	1017	174	11	126	463	57	22	277	1130	.253	.308	.396	.704	.86	1591	85	47	25	20	10	779
CLE	47	27.9	4.67	120	4527	4013	560	1005	213	14	162	529	82	28	415	975	.250	.323	.432	.755	.94	1732	79	34	29	36	23	802
DET	50	28.0	3.67	117	4398	4014	429	947	214	32	110	405	46	15	312	1140	.236	.295	.387	.683	.78	1555	74	38	5	29	12	792
HOU	43	29.2	5.50	120	4699	4135	660	1134	235	20	201	642	51	21	459	856	.274	.350	.487	.836	.119	2012	112	47	8	48	10	853
KCR	44	27.8	4.34	121	4552	4114	525	1011	210	33	125	497	95	31	345	1024	.246	.309	.404	.713	.87	1662	83	46	18	28	13	782
LAA	53	29.0	5.00	121	4679	4137	605	1044	206	14	172	577	47	15	440	890	.252	.329	.434	.763	.101	1794	112	54	2	38	22	838
MIN	45	27.9	5.73	119	4690	4212	682	1136	239	15	230	659	25	19	375	966	.270	.336	.497	.833	.117	2095	73	61	7	32	13	811
NYY	46	28.3	5.98	121	4675	4153	723	1132	217	13	218	689	43	18	447	1045	.273	.346	.489	.835	.120	2029	90	36	10	28	15	787
OAK	42	28.0	5.01	120	4602	4097	601	1004	209	14	185	560	38	19	412	961	.245	.321	.438	.760	.102	1796	102	61	3	29	12	787
SEA	61	28.0	4.87	120	4607	4091	584	987	196	21	189	567	83	31	430	1189	.241	.318	.438	.756	.103	1792	55	43	10	31	5	810
TBR	47	27.0	4.75	121	4724	4227	575	1079	220	23	163	545	72	24	413	1127	.255	.328	.434	.762	.101	1834	82	56	8	20	14	874
TEX	47	29.2	5.10	119	4560	4061	607	1009	227	21	169	576	89	31	399	1180	.248	.320	.440	.760	.91	1785	66	47	15	36	14	779
TOR	56	26.3	4.59	123	4628	4185	564	996	201	14	189	540	37	15	383	1125	.238	.305	.428	.733	.94	1792	79	27	12	20	7	754
LgAvg	46	27.9	4.90	120	4613	4132	589	1048	214	19	172	561	59	22	393	1049	.254	.323	.440	.763	.100	1817	84	45	12	30	14	809
	694	27.9	4.90	1803	69200	61975	8829	15720	3216	286	2583	8419	882	334	5890	15742	.254	.323	.440	.763	.100	27257	1263	679	181	453	205	12129

Predictive Analytics

"The use of data to forecast what will happen in the future"



Prescriptive Analytics

"The use of data to prescribe the best course of action"

As a platoon leader you are tasked to plan a convoy to move 300 soldiers from one Forward Operating Base to another. Battalion policy requires at least 6 escort vehicles (UAHs or Strykers) per convoy and a maximum of 25 vehicles per convoy. Additionally, the convoy will require you to self recover and fuel any vehicles. Your calculations for fuel consumption show that you will need to refuel one time during the operation and a fueler can carry 2500 gallons. Also, your platoon only has 4 operational Strykers and 12 LMTVs. What types of vehicles should your convoy consist of to maximize the number of soldiers transported.

	UAH	LMTV	Stryker	Wrecker	Fueler
	M1151	M1078	M1126	M984	M978
Soldiers	2	20	9	0	0
Fuel Required	25	58	53	155	155

Can you meet the mission? If not, what asset do you need to ask for to meet the mission?

Models

Models

A **Model** is an abstract representation of a system.

- Models are flexible.
- Models save time.
- Models save money
- "All models are wrong, some are useful"

Physical Model

Uses a physical construct to simulate all or part of a system

Graphical Model

Uses networks or diagrams to describe a system

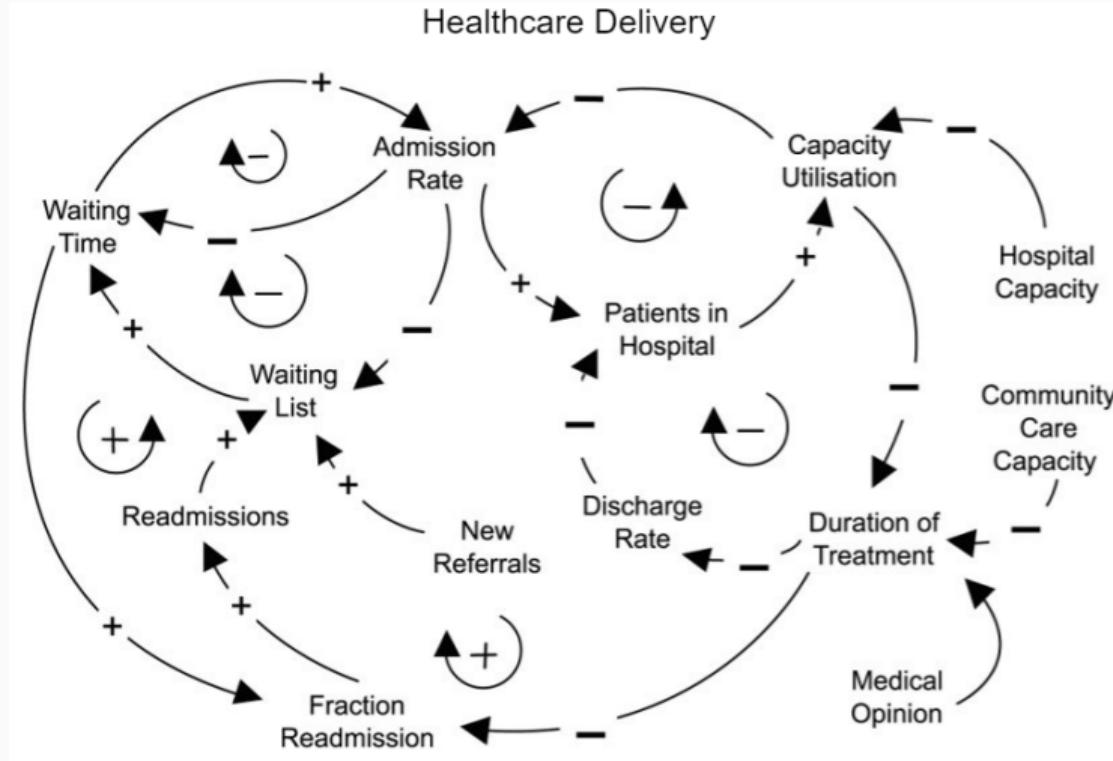
Mathematical Model

Uses quantitative relationships to describe a system

Physical Model



Graphical Model



Mathematical Model

Decision Variables:

x_1 : Number of standard bookcases produced

x_2 : Number of narrow bookcases produced

x_3 : Number of wide bookcases produced

Objective Function:

Maximize $Z = 8x_1 + 6x_2 + 10x_3$ (Profit in \$)

Constraints:

$0.2x_1 + 0.4x_2 + 0.6x_3 \leq 150$ (Trimmer time, in hours)

$0.6x_1 + 0.2x_2 + 0.5x_3 \leq 150$ (Shaper time, in hours)

$0.4x_1 + 0.4x_2 + 0.4x_3 \leq 600$ (Assembly time, in hours)

$x_1, x_2, x_3 \geq 0$ (Non-negativity)

Ethics

Informs Ethics Guidelines

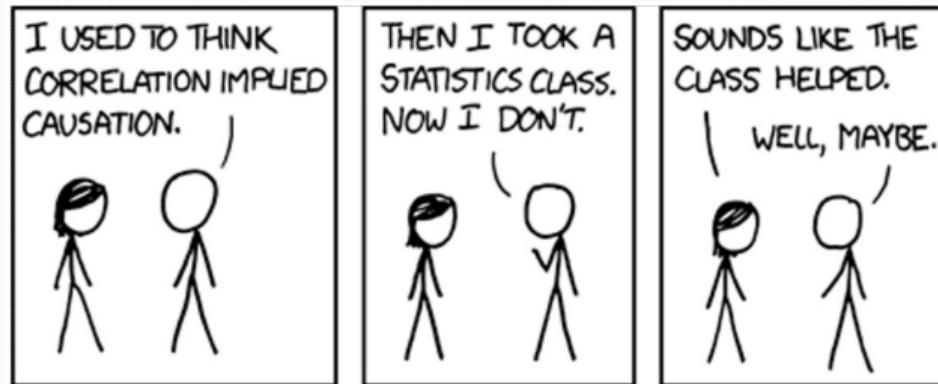


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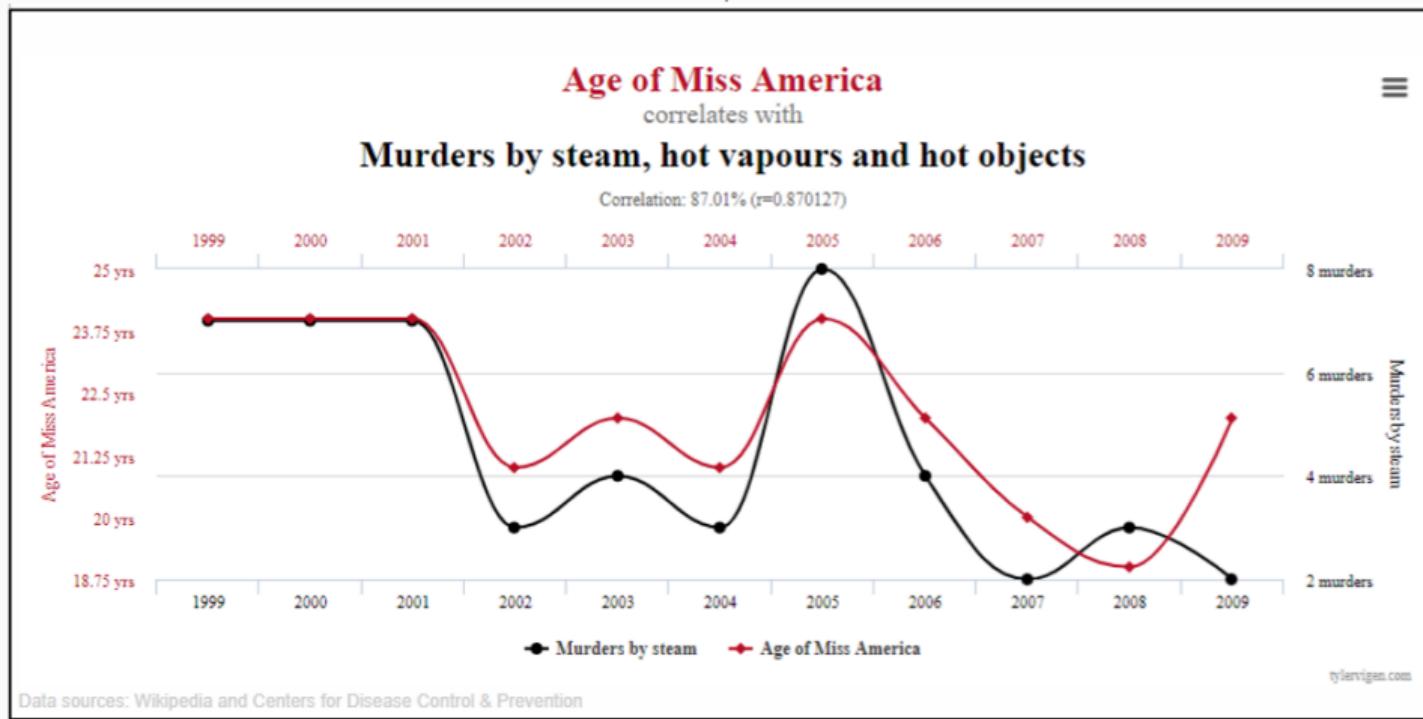
INFORMS promotes best practices and advances in operations research, management science, and analytics to improve operational processes, decision-making, and outcomes through an array of highly-cited publications, conferences, competitions, networking communities, and professional development services.

Ethical Responsibilities

- Collecting data honestly.
- Careful, holistic examination of the situation.
- Presenting data, results, and analytical model honestly.
- Impartial recommendations.
- In best interest of client while being morally suitable.

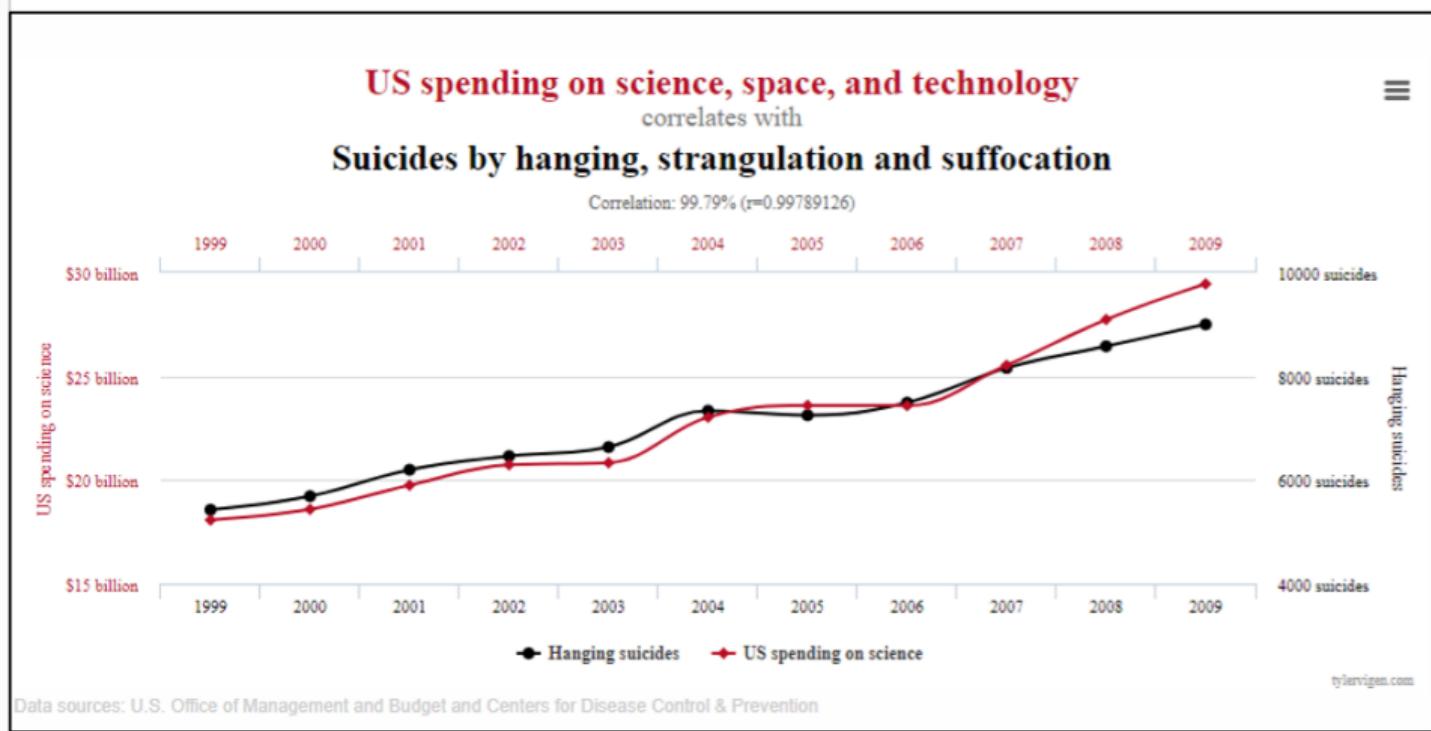


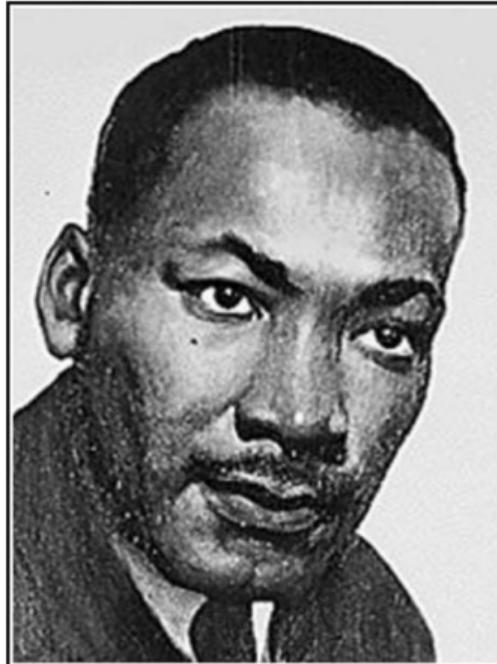
Correlation ≠ Causation



Ethical Consideration

Correlation ≠ Causation





The function of education is to teach one to think intensively and to think critically. Intelligence plus character - that is the goal of true education.

— *Martin Luther King* —

AZ QUOTES

Conclusion

Next Class

Homework: Read "The Art of Modeling with Spreadsheets" uploaded on TEAMS, chapters 21.1 and 21.2.

Next Lesson: Modeling with Spreadsheets. Bring your computer (and a mouse, if possible).