CHAPTER 2. TERMINOLOGY AND FUNDAMENTAL RISK METHODS

Problem 2-1.
A hazard is a source of potential harm while a threat is a potential intent to cause harm by exploiting a system's vulnerabilities.

Example: Exposed wiring is a hazard as it is a source of potential injury. A disgruntled employee with access to sensitive company material is a threat as he/she may intend to cause harm.

Problem 2-2.
Risk is defined as the chance of a hazard, bad consequence or loss as a result of an event or scenario. Analyzing "Risk" requires considering the probability and consequence of an event. Its concept can be linked to uncertainties associated with events. Within the context of projects, risk is commonly associated with an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives. Hence formally, risk can be defined as the potential of losses and rewards resulting from an exposure to a hazard or as a result from a risk event. In order to adequately assess all risks associated with a project, the process of identification of risk events and scenarios is an important stage in risk assessment.

The classification of risk depends on the identification and categorization of risk events and scenarios - its sources. Theses may be categorized as follows:

- *Technical, technological, quality, or performance risks*: Such as unproven or complex technology, unrealistic performance goals, and changes to the technology used or to the industry standards during the project.
- *Natural hazards*: Such as earthquakes, floods, strong wind, and waves generally require disaster recovery actions in addition to risk management.
- *External risks*: Such as shifting legal or regulatory environment, labor issues, changing owner priorities, country risk and weather.
- *Project-management risks*: Such as poor allocation of time and resources, inadequate quality of the project plan, and poor use of project management disciplines.
- *Organizational risks*: Such as cost, time, and scope objectives that are internally inconsistent, lack of prioritization of projects, inadequacy or interruption of funding, resource conflicts with other projects in the organization, errors by individuals or by an organization, and inadequate expertise and experience by project personnel.

The sources of these risks generally tend to be human, and/or economically and financially related.

Problem 2-3.
<u>Uncertainty</u>: is something or an event that is uncertain, meaning that it is indefinite, undetermined, not reliable, not know beyond doubt, not constant. In general, it is difficult to estimate a probability value of occurrence of uncertain events.
<u>Risk:</u> Probability of loss or injury, dangerous element, the chance of loss. In general, this probability can be assessed for a risky event using qualitative or quantitative methods.

Basically, risk is the result of uncertainty in, generally, an unfavorable direction.

The following example are provided:

Case	Uncertainty	Risk
(a). Grocery Warehouse automation	Will it work?	1. Orders will not be properly picked and shipped, resulting in shortages in the retail stores. 2. The automated systems might injure workers in the immediate vicinity to them.
	Will it be cost effective?	1. The automated system will cost more to install and operate than the current manual system, increasing the company's costs and reducing their already thin profit margins.
	Will the project be built as requested, on time and on budget?	1. This is getting into construction project risks. It includes the whole gamut from contractor performance, schedule delays and cost overruns, economic and financial risk, project cash flow issues, regulatory risks, etc.
	Will the change in warehouse operations after this project is complete (most likely increasing output per employee, and/or reducing warehouse employment) cause personnel problems with existing employees and/or their union?	1. The risk that existing employees would sabotage the project. 2. The risk that existing employees, in order to protest the planned loss of jobs, would stage a strike or work slowdown. 3. The risk that unions would picket or boycott your retail stores.
(b). Car starting		
b.1. Battery problems	Will the battery have	1. The battery is damaged and

	adequate output (current and voltage) to start the car?	might explode. 2. The power surge from attempting to start damages other electrical components in the car
b.2. Starting subsystem risks	Will the starting system properly activate the solenoid and starter motor, which will in turn engage the flywheel and turn the motor, thus providing motion to the starting sequence?	1. The starter and solenoid malfunction, damaging one or both of them. 2. The solenoid fails to fully engage the starter against the flywheel, damaging the flywheel (which is expensive and complicated to replace)
b.3. Fuel subsystem defects	Will the fuel subsystem a. Deliver fuel from the tank to the carburetor or fuel injectors? b. Will the fuel injectors or carburetor properly atomize the fuel to create a combustible mixture, allowing the kart to start?	1. The fuel system will malfunction and cause a fire or explosion. 1. The fuel system will flood the motor, requiring either a delay or maintenance before we can start the motor again.
b.4. Ignition subsystem defects	Will the ignition system operate properly, providing a strong enough spark at the right time in the combustion chamber so that the car can start and run?	1. The ignition timing will be off such that the motor backfires or predetonates, damaging the motor. 2. An electrical fault grounds the spark but injures the operator/mechanic.
b.5. Engine failure modes	Are the other components of the engine fully operational so that the motor will start when directed to do so?	1. The motor is already severely damaged (such as a cracked engine block). 2. The starting sequence aggravates a pre-existing condition in the motor, resulting in additional damage (such as trying to start an engine with a broken or missing timing belt/chain)
b.6. Vandalism	a. Can a vandal do something to the car to impede its ability to start? b. What secondary damage can be done to the motor from this act of vandalism?	1. The car will not start due to the vandalism. 2. The car will not only start now, but require extensive internal repairs to overcome the damage done by the vandalism (such as sugar in the gas tank, for example)

Problem 2-4.
For evaluating the performance of a transportation system of a city, we have to find out what the functional and nonfunctional requirements of system are, and then, what the ability of system to meet these requirements is. For example, in assessing the bus system of state of Maryland, the functional requirements could be the passengers moving between two distances, and nonfunctional requirements could be a timing schedule of each rout or bus.

For instance, the requirement of the a bus #44 is to be in each station in 15 minutes however the bus has two minutes delay in each station due to the fact that the driver is careless or maybe some accident happened in this rout. Therefore, these delays affect a performance of the system. Also, it should be noted that we can compare two performances of bus system in different states and figure out which one is better and what their problems are and correct them.

Problem 2-5.
Several examples of security vulnerabilities at a university campus include:

- Roadway entrances and exits onto campus where a human threat may enter the vicinity.
- The power plant facility where an explosion could cause widespread damage and power loss.
- The power grid since a disruption in the power lines could lead to local power loss of buildings.
- The computer network since a lot of valuable information can be found in university systems and they can be vulnerable to cyber-attacks.
- The financial institutes on campus since they may be holding large sums of money at a given time.
- The underground steam transfer pipes. Steam is very hot and could lead to injury/destruction if uncontrolled.
- The underground water pipe system since loss of water could lead to uncontrolled fire spread or broken pipes could lead to flooding or water damage.
- The underground sewer system in general since it could easily facilitate the movement of human threats.
- Open atmosphere environment of the campus leaving it vulnerable to aerial attack, airline crashes, or natural disasters such as meteors and hurricanes.
- The large site (area) that a campus encompasses since it can facilitate the easy hiding of hazards or human threats.
- The dorm buildings since they house a large amount of vulnerable individuals at a given time, any kind of disaster could lead to large human loss.
- The sports complexes since they also can have a large number of people inside that could be vulnerable to treats or hazards leading to large human loss.
- A classroom since there are limited exits, trapping people inside if a human threat occurred.

- The libraries since the large amount of books could easily lead to fire spread which can lead to information loss through the destruction of books or human injury due to the fire.
- The food court since food poisoning hazards could infect a large amount of people at once.

Problem 2-6.
The ISO 31000:2009 definition of risk is the "effect of uncertainty on objectives".

Example: If you wish to get a good grade on an upcoming exam (objective) but you don't know what specific material will be covered (uncertainty), then you risk studying the wrong material and failing the exam (effect).

Problem 2-7.
Risk assessment is one of three primary elements of risk analysis in conjunction with risk management and risk communications. It is a technical and scientific process of determining the potential loss, injury, and sources of hazards in either or both qualitative and quantitative ways. It should answer the following questions:

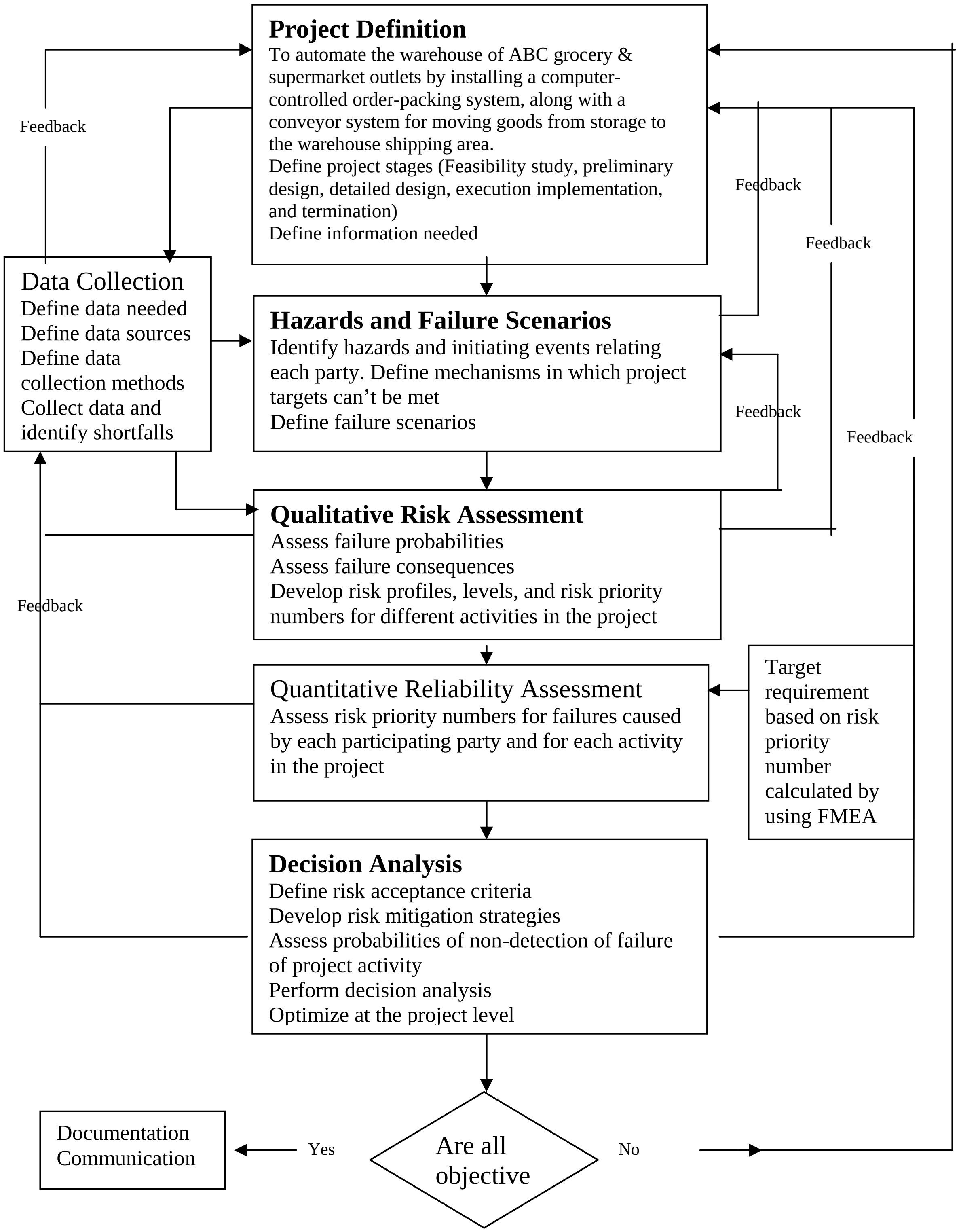
1. What can go wrong that could lead to exposure of hazard? (Scenario: Si)
2. How likely this can happen? (Likelihood: Fi)
3. If it happens, what consequences (e.g., loss) are expected? (Consequences: Ci)

And, risk is expressed as {<Si, Fi, Ci>}

Uncertainty in business environment, which is associated with the profit as a random variable, has become increasingly important in decision-making. Risk assessment can be done in the following manner by taking into consideration of uncertainty in each step.

1. Definition of system (e.g., objects, system boundaries)
2. Hazard identification (e.g., risk events and scenarios)
3. Collection of data in a life-cycle framework
4. Qualitative risk assessment
5. Quantitative risk assessment
6. Management of system integrity through failure prevention and consequence mitigation using risk-based decision making

In order to achieve the risk assessment in this manner, there are several methodologies. They include 'What-if', 'Preliminary Hazard Analysis (PrHA),' 'Failure Modes and Effects Analysis (FMEA),' 'Fault Tree Analysis (FTA),' and 'Event Tree Analysis (ETA).' PrHA is a semi-qualitative and quantitative analysis that can find out undesirable consequences in the early life cycle of the system. FMEA is an inductive methodology, which is relatively easy to use and yet a powerful tool that helps to identify and counter weak points in the early conception phase of products and processes. While, FTA is a deductive, top-down method typically performed graphically using logically structured AND or OR gates. It involves specification of a top event for analysis, followed by the identification of all associated elements in the system causing the top event.



Risk Based Lifecycle Management for the Warehouse Automation Project

Problem 2-8.
This problem deals with starting an automobile by turning the automobile key in the starter switch based on limiting the system to the following potential failure modes: battery problems, defects in the starting subsystem, defects in the fuel system, defects in the ignition subsystem, engine failure modes, a vandalism act that causes the automobile not to start, and other failure modes. Risk events categories and scenarios from the perspective of the customer can be presented as follows:

Car starting	
Technical, quality or performance risks	This category includes the quality of the components used in the assembly of the automobile. The low quality of the products and the complexity of the engines and components of automobile.
Economic Risks	This category includes the labor fees of the mechanics and the dealer to fix the defected components. It also consider the time of fixing the automobile and whether the cost has an effect on the maintenance of the automobile.
Dealers or Mechanics Risk	Low skills mechanics or the dealer labor might affect the overall maintenance cost. Using cheap or low quality parts in fixing the problem. It also fixing unnecessary part to maximize the profit of the dealer or the mechanic.
Environment Risk	This includes climate effects on the automobile such as hot and cold weather, humidity effects, dust or sand effects, which may affect the failure of any component of the automobile.
Conflict among individuals	Conflict among manufacturer, dealers and mechanics that pose risk on customer. For example, the conflict of using unfamiliar part in fixing a problem. The conflict may arise if using malfunction parts in the assembly of the automobile. Another conflict also may arise of changing any part without approval of the customer.
External Risk	Vandalism by car theft or vandalism by the mechanic to create additional work for them.

Problem 2-9.
The risk breakdown structure associated with ABC grocery project can be presented in a table format as follows:

Risk Breakdown Structure Associated with ABC Grocery Project

Level 0	Level 1	Level 2	Level 3
	Project Management Risks	Team Management	Risk arising from productivity of team members. Risk arising from alignment of human resources. Risk arising from conflicts among team members.
		Stakeholders	Risk arising from the acceptable level expected. Risk arising from conflicts between ABC and other stakeholders.
		Customers	Risk arising from adapting new approach and if it would meet customers satisfaction.
		Corporation	Risk arising from ABC expectations and their level of satisfaction from the project. Risk arising from the ABC strategies and regulations that might affect the project.
ABC Project Risks	External Risks	Rules and Regulation	Risks associated with the regular constraints and standards that could impact the project. Risks arising from changes in regulations that might impact the project.
		Economic and Financial Risks	Risks related to economic situation and it's impact on the project financing. Risks arising from competition and its impact on the project. Risks arising from ABC ability to continue to fund, finance, and maintain payments to the project.
	Technological Risks	Performance	Risks arising from the implementation of new technological software. Risks arising from changes in technologies after the project adoption of a certain technology.
		Applications	Risks arising from how easy it is to implement a new software technology. Risks arising from the maintenance of the new technology. Risks arising from changing the current protocol to new technology.

Problem 2-10.

(a) Using Problem 2-8 to analyze and assess risks associated with automobile system that could lead not being able to start the automobile, the FMEA Table is as follows:

FMEA Table of Automobile System

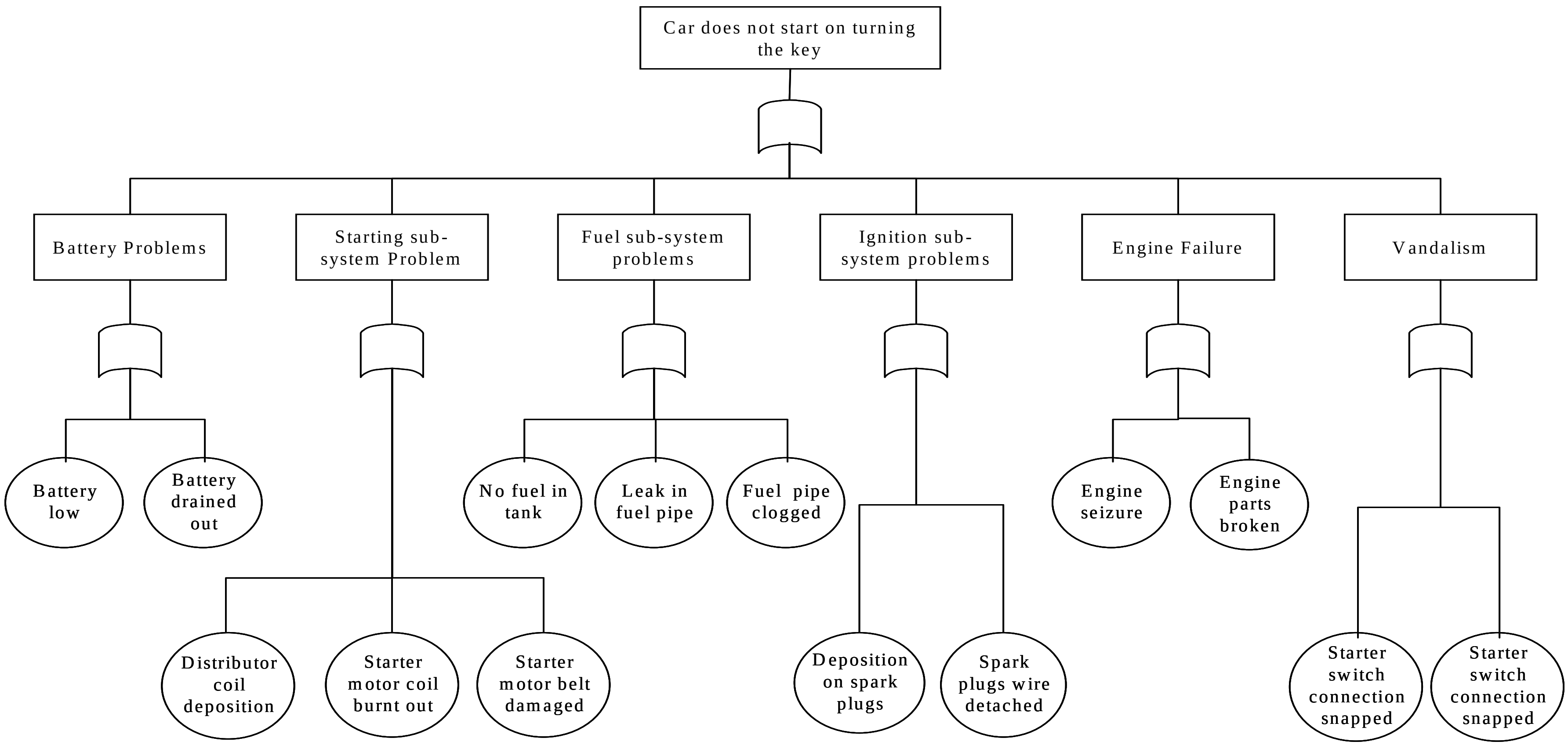
Source of risk	Failure Mode	Failure Effect	SEV[1]	Causes	OCC[2]	Controls	DET[3]	RPN[4]
Battery	Cable Defects	Failure to carry the current	3	Wearing out	5	Visual inspection	6	90
	Clamps and Terminals	Failure to maintain correct electrolyte levels	2	Loose	6	Visual inspection	6	72
	Corrosion or oxidation	Failure to maintain correct electrolyte levels	4	Weather	5	Visual inspection	5	100
	Alternator belt	Failure to Charge the Battery	4	Tension	3	Visual inspection	3	36
	Filler Tubes	Failure to meet the required amount of Liquid	5	Low or Overfilled	3	Visual inspection	4	60
	Plates	Failure to create chemical reaction	5	Not sealed correctly	6	Visual inspection	5	150
Fuel Subsystem	Carburetor	Failure to supply fuel to the engine	9	Bad fuel mix	5	Proper diagnostic test	5	225
	Main circuit	Failure to control the amount of fuel for efficient cruising	4	Not enough fuel provided	4	Proper diagnostic test	6	96
	Accelerator Pump	Failure to provide burst of fuel when the pedal is depressed	4	Not enough extra fuel provided to reduce hesitation	5	Proper diagnostic test	5	100
	Fuel Injector	Failure to open and close valves	8	Not enough spray to the intake valve	6	Proper diagnostic test	6	288

Engine Subsystem	Piston	Failure to move up and down	9	Worn out allowing air/fuel to leak	4	Proper diagnostic test	3	108
	Cylinder	The cylinder has a hole	9	The gasket breaks down	7	Proper diagnostic test	5	315
	Exhaust Port	Failure to open the exhaust valve	8	Not sealed properly allowing leak during compression	5	Proper diagnostic test	4	160
	Crank Shaft	Turn the piston motion to circular motion	7	Worn out allowing air/fuel to leak	6	Proper diagnostic test	5	210
	Combustion Chamber	Failure to maintain proper compression and combustion	8	Lack of gas so the engine is getting air but no fuel	7	Proper diagnostic test	7	392
	Valves	Failure to open and close valves	8	Do not open or close at the right time	6	Proper diagnostic test	5	240
Ignition Subsystem	Ignition Wires	Failure to carry electrical charge	7	Worn out or missing wires	4	Visual inspection	5	140
	Distributor	Failure to distribute charges to the Spark plugs	7	Charges not sent properly to the spark plugs	5	Proper diagnostic test	5	175
	Spark Plugs	Failure to create electricity to arc across the gap	7	Spark might be nonexistent or weak	5	Electric diagnostic tests	4	140
	Coil	Failure to generate high voltage to create spark	5	Worn out or not working properly	4	Electric diagnostic tests	5	100

Starting Subsystem	Neutral Safety Switch	Failure to sense the neutral or parked gear	4	Switch is worn out	4	Diagnostic test	4	64
	Starter Relay	Failure to allow current between the battery and the starter motor	6	Not enough voltage	5	Diagnostic test	4	120
	Starter Solenoid	Failure to ignite fuel and air mixture	7	Fuel not ignite at the right time	5	Proper diagnostic test	4	140

1: SEV= Severity of the effects of the failure
2: OCC= Probability of failure occurring
3: DET= likelihood failure is detected
4: RPN= Risk priority number = (SEV) × (OCC) × (DET)

(b)The Fault Tree diagram of the Automobile System can be drawn as follows:



Problem 2-11.
(a) Using Problem 2-3a to analyze and assess risks encountered by the contractor company constructing automated warehouse project, the FMEA table of the contractor company can be presented as follows:

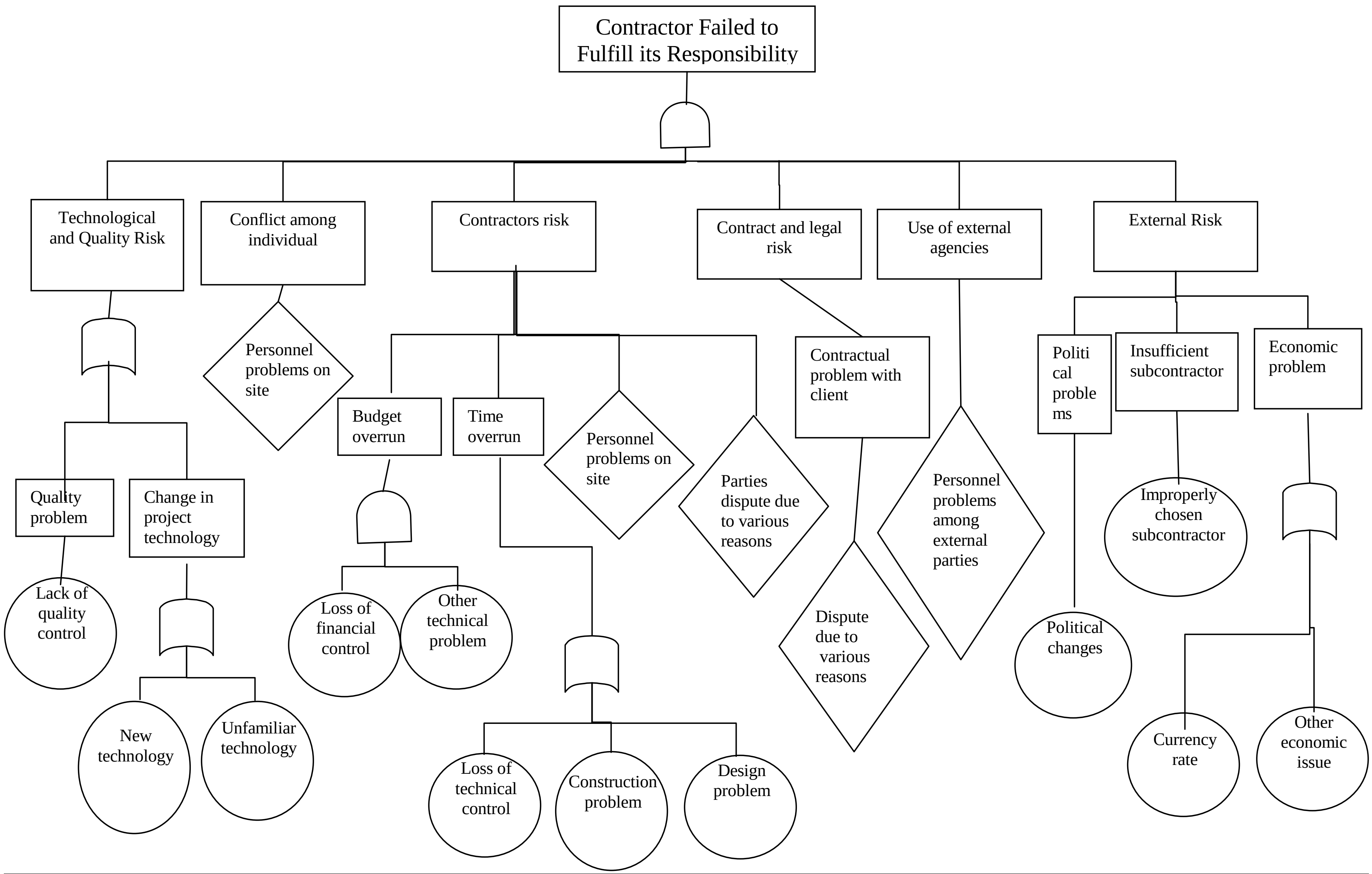
Source of risk	Failure Mode	Failure Effect	SEV[1]	Causes	OCC[2]	Controls	DET[3]	RPN[4]
Technological, quality, or performance risk	Quality problems	Failure to meet project requirements	8	Lack of establishing good quality standard, at the beginning of the project	5	Quality manual prepared and distributed to all parties involved	6	240
	Changes in project technology	Failure to cope with changes	6	Staff is not well prepared to accept changes	6	Organize to make staff aware of new changes	6	216
	Difference in project technology	Failure to construct properly	7	Unfamiliar, new technology	5	Organize to make staff aware of new technologies	6	210
Conflict among individuals	Personnel problems	Arbitration and delay in finishing the project	7	Multinational or labor from diverse background Different work attitudes or language	4	Organize periodic meeting to resolve these problems	6	168

Contractors risks	Budget overrun	Failure to finish the project within budget	9	Loss of control on financial matters of the project in addition to some other technical problems	6	Increased levels of financial and technical monitoring, and auditing or project activities	5	270
	Failure to finish project on time	Failure to deliver project to the client's expectations	7	Loss of technical control due to construction problems, design problems or incompetent contractor	4	Increased periodic technical control and tracking program of actions	6	168
Contract and legal risks	Contractual problem with client	Disputes with client	4	Contractor misunderstood requirements	4	Explain to clients in detail the scope of services throughout the project	5	80
		Failure to complete contracted project	3	Contractor failed to fulfill its responsibility	4	Make provisional precautions before signing contract with client	5	60
Use of external agencies	Failure to cope with external parties effectively	Problems among parties leading to total chaos	5	Lack of organization on site as a result of bad planning	4	A discipline is needed in selecting subcontractors and control and monitoring procedures	4	80

External risks	Economic problems	Failure to make profit as anticipated	6	Contractor did not account for changes in currency rate or similar economic issues	5	Perform effective marketing study before engaging in project	6	180
	Inefficient subcontractors	Problems in delivery and with subcontracted work	5	Contractor chosen is improper or problems appear between contractor and his subcontractor	6	Ask for a list of all selected subcontractor	4	120
	Political problems	Difficulty in providing contracted work efficiently	4	Contractor did not anticipate political changes	7	Perform uncertainty and risk analysis studies before accepting to work on a project	3	84

1: SEV= Severity of the effects of the failure
2: OCC= Probability of failure occurring
3: DET= likelihood failure is detected
4: RPN= Risk priority number = (SEV) × (OCC) × (DET)

(b)The Fault Tree diagram of the contractor failure for the warehouse automation project



Problem 2-12.
The median return on investment is about $155m. The standard deviation, from rough estimations associated with the binned data, is about $83m. The project is acceptable given a cash reserve of $100m because it has a low probability (4.7) of lost investment.

Problem 2-13.
Risk appetite is the amount and type of risk that an organization is willing to pursue or retain. In different words, risk appetite is something to do with willingness to take risk, or an extent to which a person or organization will take risk, or do something risky. “Risk Appetite” is often seen as synonymous with “Risk Attitude” though it is not. Risk attitude is an organization’s approach to assess and eventually pursue, retain, take or turn away from risk. In fact, risk attitude is the chosen response of an individual or group to uncertainty that matters, driven by perception. For example, we have a construction company and participation in bidding for construction of residential building. Our risk appetite could be reducing the offered project cost to win the bid. And, our risk attitude could be perceptions and considerations that project managers decided to consider in project scope.

Problem 2-14.

a) Risk Aversion – Having the attitude to turn away from risk (Ayyub Ch2, Pg 16). Examples include:
   - Avoiding a business project based on the potential for it to go over budget.
   - Avoiding buying any house in case the housing market crashes again.
   - Avoiding buying a particular house because it is over 50 years old and there is a risk it could have plumbing, electrical, or structural problems.
   - Taking a train instead of a plane because of the potential risk of a fatal air traveling accident.
   - Not traveling to other countries because of the risk of something bad happening there and not being able to get back home.
   - Not surfing because of the risk of sharks.

b) Risk Seeking – Having the attitude to pursue, retain or undertake the risk for potential return (Ayyub Ch2, Pg 16). Examples include:
   - Investing in a certain stock in the stock market that has the potential for big gain but might not be reliable.
   - Going skydiving because of the reward of feeling alive but knowing of the risk of death.
   - Playing professional football because of the reward of fame and money but knowing of the risk of injury.

- Starting your own business since there is the risk of failure but the reward of being in charge and making money.

c) Risk Neutrality – Having the same attitude towards risks regardless of potential loss (Ayyub Ch2, Pg 16). Examples include:
   - Choosing two work projects with totally different risk amounts but the same monetary reward just to make the money.
   - Crossing a 1000 foot bridge and then a 10 foot bridge without thinking twice about either.
   - Working in a very safe, highly equipped chemical laboratory and then performing the same chemical experiments at home that night.
   - Robbing a bank and then pickpocketing an old person on the metro when traveling home.

Problem 2-15.
A number of categories were developed to place each type of activity or technology into its main group. Afterwards, a simple probabilistic analysis was done to see how the non experts compare to the experts. The categories are as follows: Chemical/Weapon, Travel, Medical, Employment/Work Related, Sports, Appliances, Energy Generation, and Food.
Chemical/Weapon: Hand guns, pesticides, spray cans
Travel: Motor Vehicles, motor cycles, railroads
Medical: Smoking, alcoholic beverages, surgery, contraceptives, x-rays, prescription antibiotics
Employment/ Work Related: General aviation, police work, firefighting, heavy construction, commercial aviation
Sports: Hunting, mountain climbing, bicycles, swimming, skiing, high school or college sports
Appliances: Power mowers, home appliances
Food: Food preservatives, food coloring
Energy Generation: Nuclear power, Electric (non- nuclear) power

By examining ratio values in the table below, observations can be made on League of how the Women Voters (LV) and College Students (CS) compare to Experts. A value less than 1 indicates underestimation of risk while a value greater than 1 indicates overestimation of risk as compare to the experts.

Chemical/Weapon				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Hand guns	3	2	4	0.75	0.50
Pesticides	9	4	8	1.13	0.50
Spray cans	14	13	25	0.56	0.52

Travel				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Motor vehicles	2	5	1	2.00	5.00
Motorcycles	5	6	6	0.83	1.00
Railroads	24	23	19	1.26	1.21

Medical				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Smoking	4	3	2	2.00	1.50
Alcoholic beverages	6	7	3	2.00	2.33
Surgery	10	11	5	2.00	2.20
Contraceptives	20	9	11	1.82	0.82
X-rays	22	17	7	3.14	2.43
Prescription antibiotics	28	21	24	1.17	0.88

Employment/ Work Related:				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
General aviation	7	15	12	0.58	1.25
Police work	8	8	17	0.47	0.47
Firefighting	11	10	18	0.61	0.56
Heavy construction	12	14	13	0.92	1.08
Commercial aviation	17	16	16	1.06	1.00

Sports				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Hunting	13	18	23	0.57	0.78
Mountain climbing	15	22	28	0.54	0.79
Bicycles	16	24	15	1.07	1.60
Swimming	19	29	10	1.90	2.90
Skiing	21	25	29	0.72	0.86

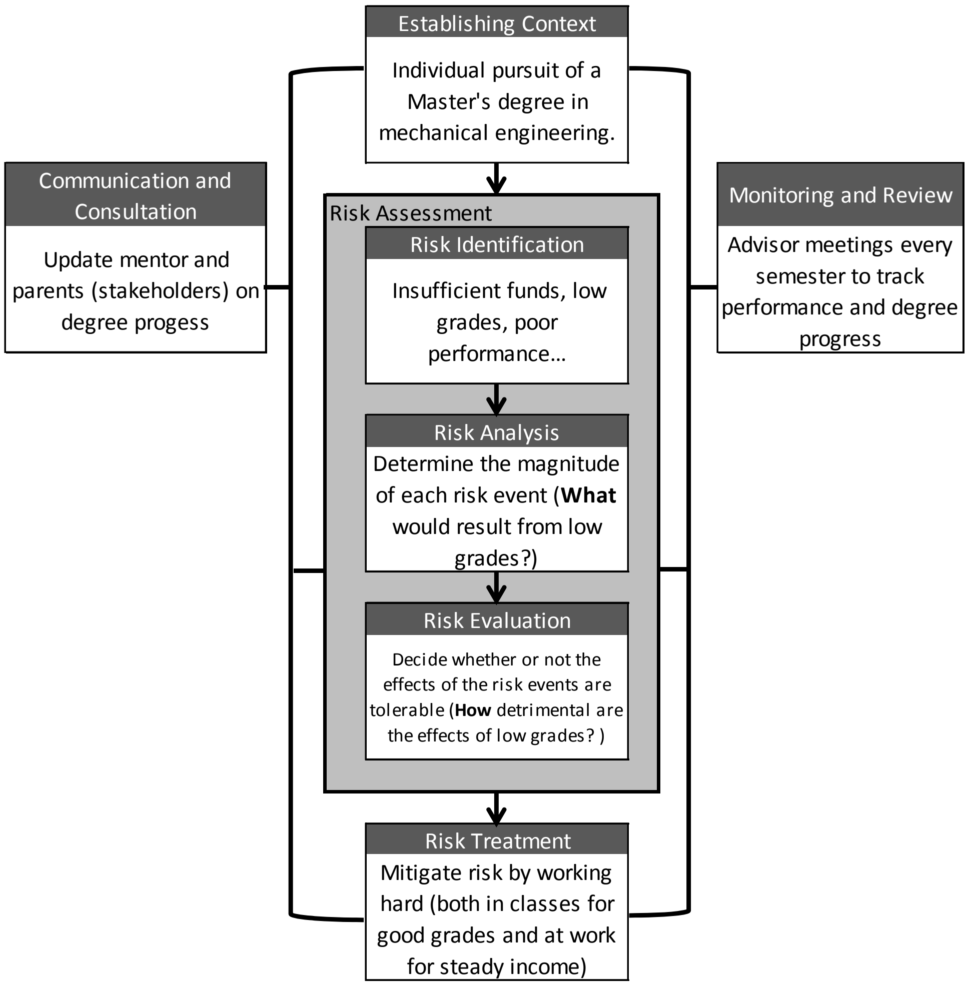
High school or college sports	23	26	26	0.88	1.00

Appliances				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Power mowers	27	28	27	1.00	1.04
Home appliances	29	27	22	1.32	1.23

Food				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Food preservatives	25	12	14	1.79	0.86
Food coloring	26	20	21	1.24	0.95

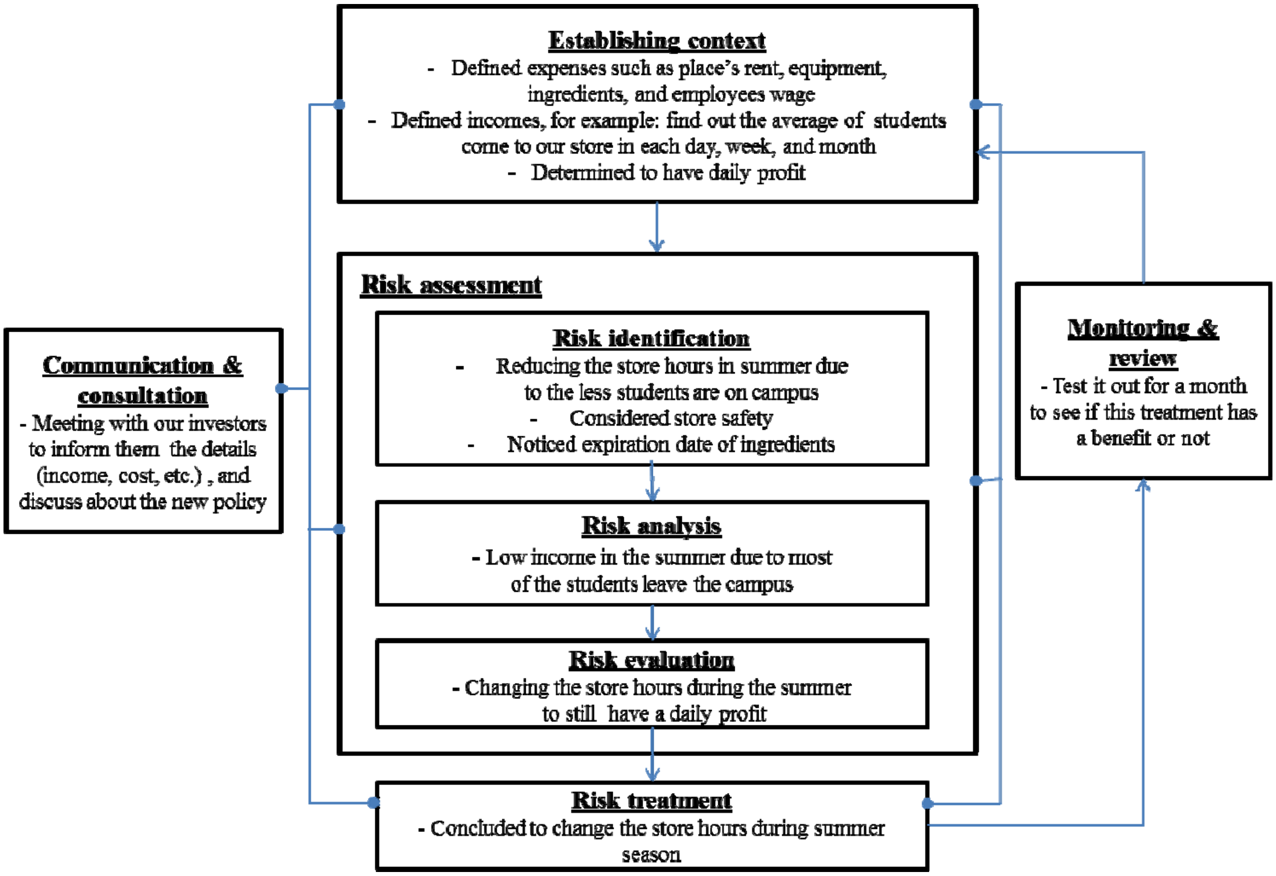
Energy Generation				Comparison (LWV)	Comparison (CS)
Activity/ Technology	**League of Women Voters**	**College Students**	**Experts**		
Nuclear power	1	1	20	0.05	0.05
Electric (non- nuclear) power	18	19	9	2.00	2.11

Problem 2-16.

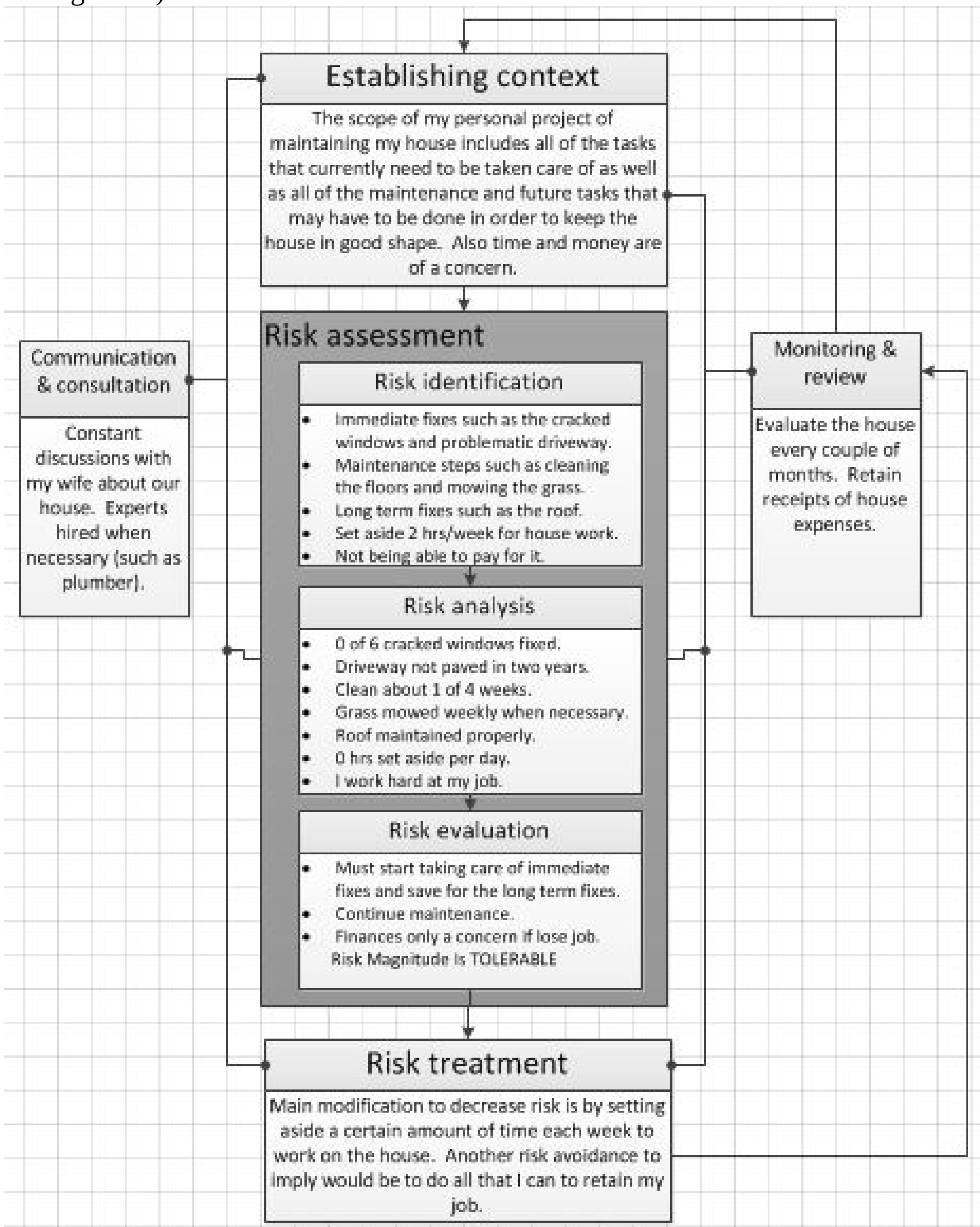


Problem 2-17.

Our business is Coffee shop on College Park Campus: (ISO31000-2009 Risk Management Methodology)

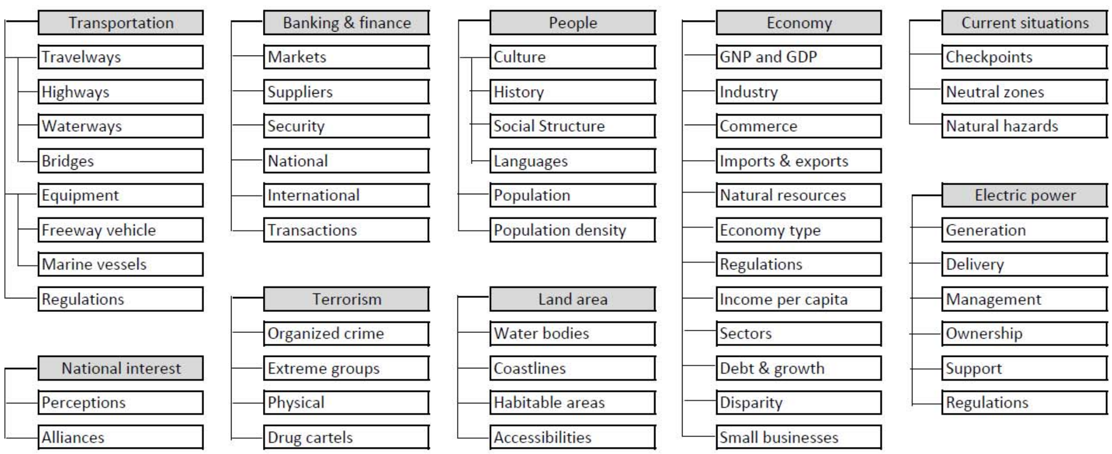

Establishing context
- Defined expenses such as place's rent, equipment, ingredients, and employees wage
- Defined incomes, for example: find out the average of students come to our store in each day, week, and month
- Determined to have daily profit
Risk assessment
Risk identification
- Reducing the store hours in summer due to the less students are on campus
- Considered store safety
- Noticed expiration date of ingredients
Risk analysis
- Low income in the summer due to most of the students leave the campus
Risk evaluation
- Changing the store hours during the summer to still have a daily profit
Risk treatment
- Concluded to change the store hours during summer season
Communication & consultation
- Meeting with our investors to inform them the details (income, cost, etc.) , and discuss about the new policy
Monitoring & review
- Test it out for a month to see if this treatment has a benefit or not

Problem 2-18.
Managing a Personal Project, Maintaining My Home: (ISO31000-2009 Risk Management)



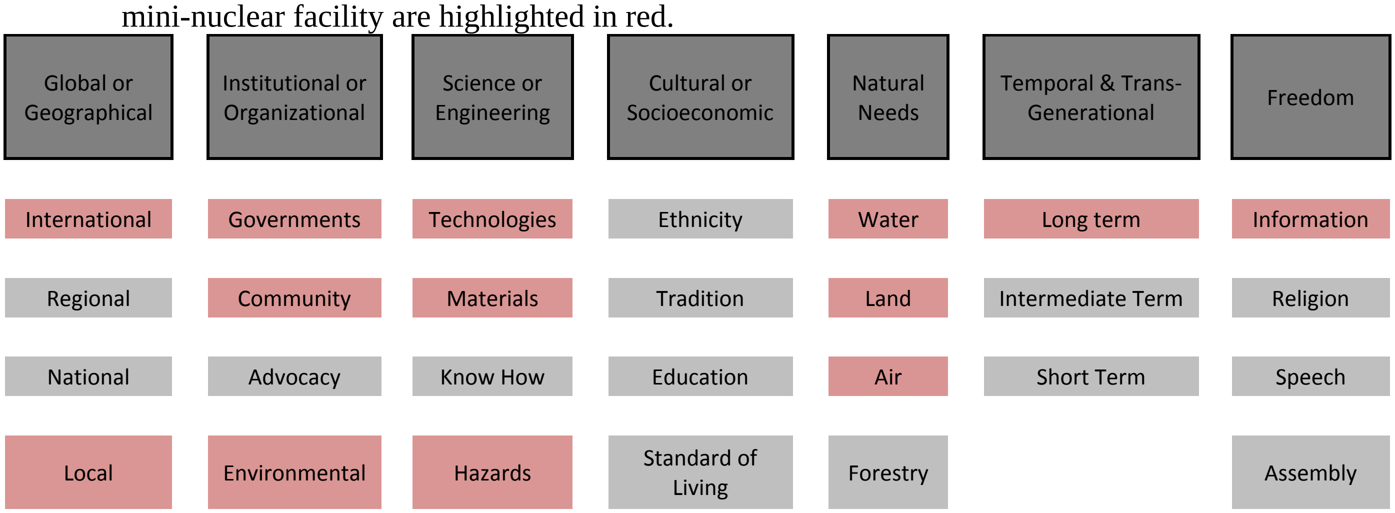
Problem 2-19.
Designing and building a bridge between two countries inherently has its associated risks. These risks can be broken down by category using a risk breakdown structure as shown

in the figure below. Fortunately for this project, the two nations have strong political and economic ties. Still there are many economic risks; for example, commerce. Say one nation has recently constructed a new mall near the bridge. It may attract people from the neighboring nation, which could create economic growth for that nation and hurt the other nation. Transportation is another obvious risk category. The new bridge is to be constructed over an existing water-navigation channel. So along with the risks associated with freeway vehicles, there will be the additional risks for marine vessels. Construction could cause major delays in waterway travel. Risks associated with the people of the two nations are another major category. Population density could shift between the border cities, cultures could mesh, and crime could potentially increase. Along with crime, there is the category of terrorism. A bridge connecting two countries could be seen as a target for an internal terrorism group, since the bridge greatly affects transportation, the economy, and people. Additional categories, but not all, are listed below.



Problem 2-20.

Figure 2.9 is a simplified version of the chart in Figure 2.8. As such, Figure 2.9 was used to identify applicable risk categories. The risk categories pertaining to the protection of a mini-nuclear facility are highlighted in red.



Ecological Justice Food Governance

Equity Ecology Transactions

In terms of global/geographical risk, both international organizations (who have stock/interest in the nuclear industry) and the local government would likely monitor the facilities actions very carefully. As harvesting nuclear power is a risky endeavor, local governments/communities and environmental protection groups are likely to resist the installation of such a facility and pose a significant threat. The categories within science/technology and natural needs that serve as risk factors for the protection of a nuclear facility are somewhat self-explanatory. The technology and materials that will likely be used are very valuable and need to be secured. In addition the nuclear plant itself poses ecological (contamination of water, land, air) and human safety hazards that are will likely be opposed by human threats. As the facility will be in place for over 10 years, the plant must protect itself against long-term threats. Within the final category (freedom), the desire for freedom of information (about the inner workings of the facility) will likely draw contention from some people.

Problem 2-21.

level 0	level 1	level 2	level 3
project risks	management	corporate	unfamiliar with custom design implementation
			communication between architect and structural engineer
			other projects being done by the company
		customers and stakeholders	homeowner's vision of house and source of income
			design changes from architect and structural engineer
	external	natural environment	upcoming natural disasters
			seasonal weather changes that deter construction
			accesibility of site
			water table on site
			source of materials
		cultural	permit process
			neighborhood reaction
		economic	cost of labor in location
	technology	requirements	change orders for new technology specified incorrectly
		applications	unfamiliarity by labor with correct implementation

Problem 2-22.
Risk breakdown structure for an advertising company/agency based on Facebook (network):
- Advertising agency:
    1- Customers orders Ads
    2- FB members: audience for Ads

Level 0: **Enterprise (Company)**	**Level 1:** **Prospect (resources)**	**Level 2:** **Pricing**	**Level 3:** **Execution**
Strategic:	Technology	Reasonable	Behind the schedule for delivering product
Reputational damage: - Sending spam and unwanted emails to members or using private information without user's knowledge			
Competition: - Other more successful advertising companies	Labor (employment)	Unmanaged assumption	Not satisfying the customer
Customer needs: - Not paying attention to member's feedback	Equipment (computers/software)	Local codes and standards	Trouble in
Demographic: - N/A: FB is an universal social network however social & cultural trends can be possible sources of risk	Subcontractors (software engineer) (application developers)	Scope definition	Post execution (evaluating the effectiveness of content) (statistic of how many visitors seen the Ads or click on them
Social/Cultural events: - Ads should be appropriate to cultural performances of FB members	Commercial (Ads for company)	Technical resources	
Technological innovation: - Using updated algorithms for doing customized advertising	Technical	Timing	
Capital availability: - If the available capital is limited, policies should be taken to absorb more investments		Work load	
Financial:			
Price (cost): - Payments for each ad to FB network. (reasonable price)			
Liquidity: - Source of income is customers payments for each Ad			
Credit: - Initial investment should be enough & covering			
Inflation/purchasing power: - Economy & member's income is having direct impact on the business			
Operations:			
Business opportunities:			

- Consulting with a law firm			
Information: - Reliable sources of data about member's preference			
Information/business reporting: - Evaluation of company performances based on customers/FB members feedback			
Hazard:			
Legal complications : - Privacy of members - Improper advertisement - Being used by any other advertising company or FB members			
Security - Threat of identities & private information of member			
Business interruption - Conflict of interest with any other Ad company			
Liability claims - Claims based on authority or privacy of the members or other advertising company			
Assets:			
Customer related - Choosing the right customer			
Hiring - Choosing the right employees			
Organization - Consulting the right companies (law firm)			
Financial - Right resource allocation			
Environment:			
Market - Understanding market needs			
Legal or regulatory - Taking into account all limitations imposed by law (privacy)			
Competition - Other more successful advertising companies			

Problem 2-23.

Initial event and cause table		
event	condition	causes of event
crane arrives on site	crane was too small for task	resizing of girder
worker uses crane to lift girder	crane inable to lift the girder	miscommunication
crane topples		

Barrier Analysis Table			
Barriers to Prevent Accident	Barrier Performance	Reasons for Barrier Failure	Evaluation of Effect
side bracing of crane	bracing gave out	too small for the load	bracing was unable to stabilize crane
specifucation of crane size	incorrect crane specified	crane size not reconsidered after design change	crane was insufficient for the load

---

Problem 2-24.

Accidents of Nail Striking Workers, Event & Casual Factor Analysis

Initial Event and Cause Table		
Event	**Condition**	**Causes of Event**
Company bought nail gun	Nail gun did not have safety mechanisms	(to be entered later once known)
Worker used nail gun	Nail gun was bulky	
Nail went into worker's foot		

Barrier Analysis Table			
Barriers to Prevent Accident	**Barrier Performance**	**Reasons for Barrier Failure**	**Evaluation of Effect**
B1) Safety button on nail gun	Non-existent	The nail gun was the cheapest version	Nail gun fired prematurely
B2) Extra attention by worker	Did not happen	Worker was trying to get job done quickly	Worker not paying attention to gun

Change Analysis Table			
Situation at Time of Accident	**Prior, Ideal, or Accident-Free Situation**	**Difference**	**Evaluation of Effect of Change**
End of work day, worker was in rush	Worker worked slightly longer & gotten paid	Worker would not have rushed	C1) Worker was in a rush since no overtime pay
Worker was working alone	Additional co-workers to help the worker	Worker was trying to finish work alone	C2) Because there were no other employees, worker was rushing

Updated Event and Cause Table		
Event	**Condition**	**Causes of Event**
Company bought nail gun	Nail gun did not have safety mechanisms	Nail gun was least expensive available
Worker used nail gun	Nail gun was bulky	Worker not aware of weight
Nail went into worker's foot		B1) Safety button on nail gun B2) Extra attention by worker C1) Worker was in a rush since no overtime pay C2) Since no other employees, worker was rushing

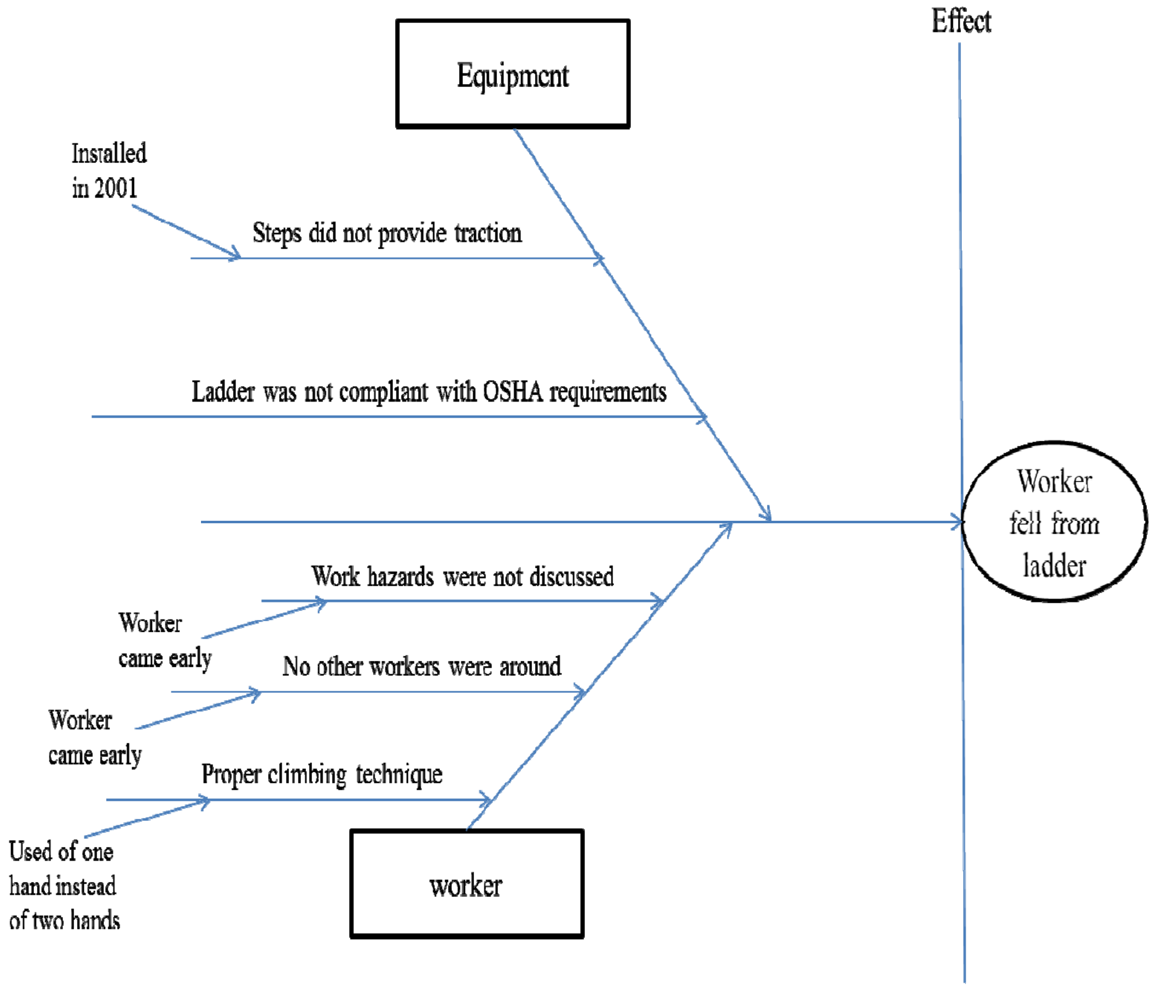
Responsibility Level Table		
Management Tier	**Causal Factor**	**Responsibility**
Equipment Manager	B1) No safety button on gun	Failure to provide proper gun
Human Resources	C2) Not enough employees	Failure to hire more employees
Worker	C1) Worker in a rush	Did not pay attention to task

Problem 2-25.

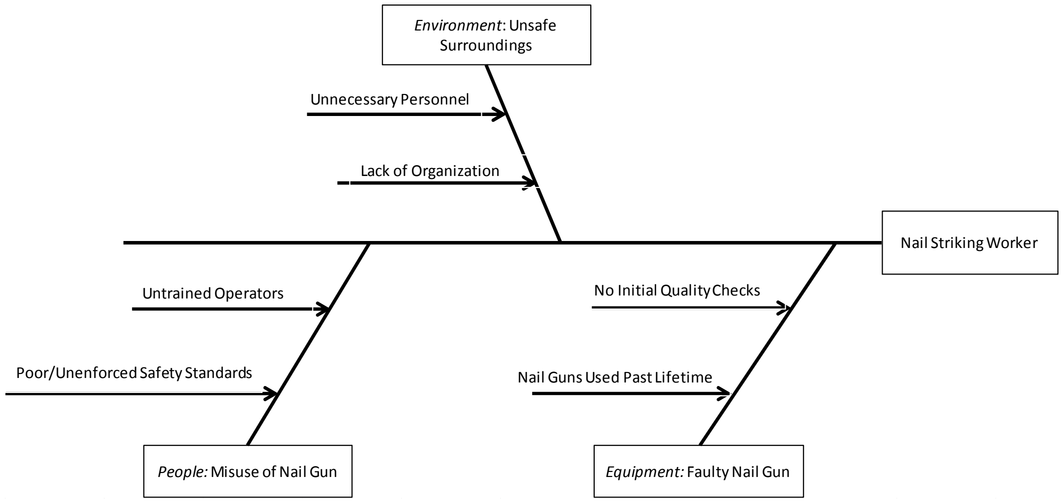
Initial event and cause table:		
Event	Condition	Causes of the event
Mine used to mine coal	Standards set by Mine Act of 1977	Minimal safety requirements
Miners descend into mine	High methane levels present	Poor ventilation systems
Miners die from explosion		

Barrier analysis table:			
Barriers to Prevent Accident	Barrier Performance	Reasons for barrier failure	Evaluation of Effect
Barrier 1: Toxic gas detector	Battery died	No replacement batteries	High methane levels were not detected
Barrier 2: Proper ventilation system	Inadequate	Not enough fans and poor exhaust	Poor air exchange rate

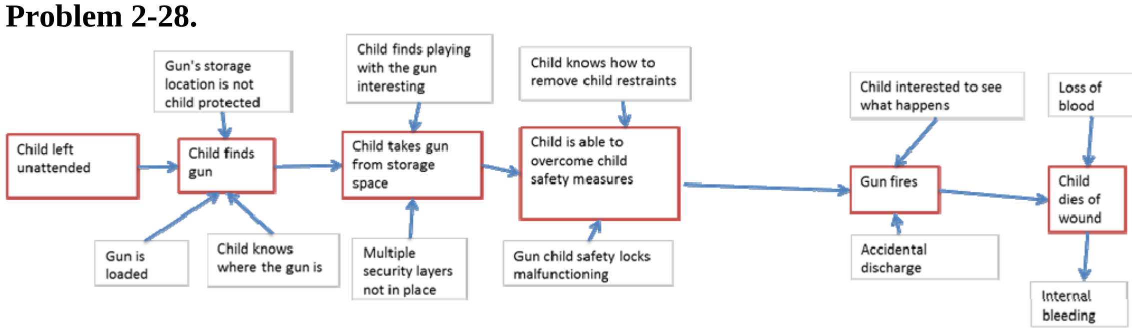
Problem 2-26.
Ishikawa diagram for the case that a worker falling from a ladder: (Section 2.4.3.1)



Problem 2-27.
The Ishikawa diagram developed for this problem details the causes of nail gun injuries. The three primary causes are: an unsafe workplace, misuse of the nail gun, and faulty equipment. The secondary causes given are examples of several possible underlying factors that lead to nail gun injuries.

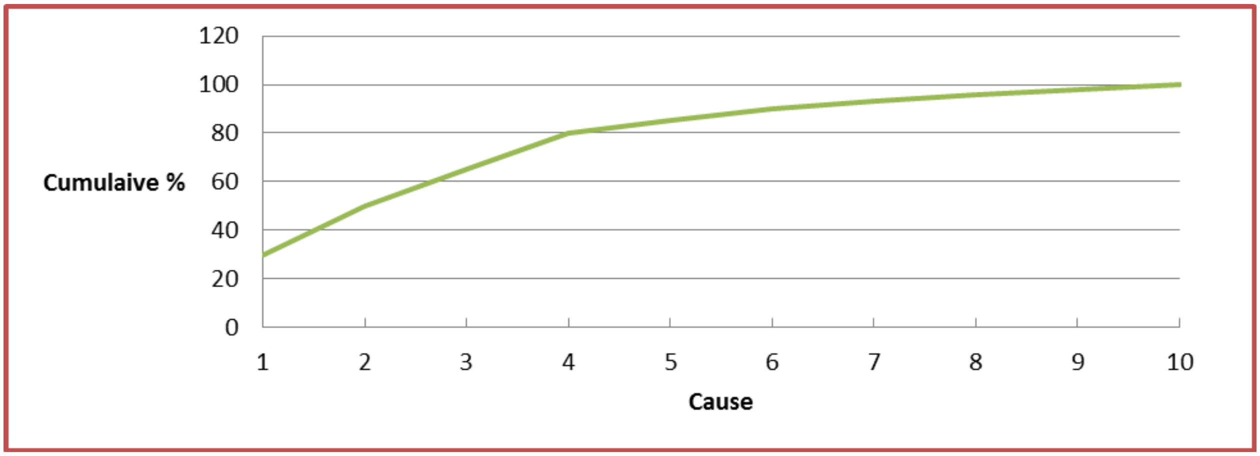


Problem 2-28.



Problem 2-29.

Cause	Importance of Cause	Cumulative Percentages
1. Gun is loaded	30	30
2. Gun's storage location is not child protected	20	50
3. Child's knows where the gun is	15	65
4. Multiple security layers not in place	15	80
5. Child knows how to remove child restraints	5	85
6. Gun child safety locks malfunctioning	5	90
7. Child interested to see what happens	3	93
8. Accidental discharge	3	96
9. Internal bleeding	2	98
10. Loss of blood	2	100



Most Important Casual Factors:
Gun is loaded
Gun's storage location is not child protected
Child's knows where the gun is
Multiple security layers not in place

Also, the following is offered:

Number	Root Cause	Mitigation Technique	Stopping Power	Life Saving Scope	Ease of implementation	Score	rank
1	The Child found the gun	Store gun in a location unknown to Child	7	10	8	560	1
2	The Child was able to take the gun from its storage location	Lock gun very securely in storage location	9	10	9	810	2
3	The gun was able to discharge (loaded and safety off or compromised	Better safeties and firearms that cannot be operated without a key	6	10	5	300	3

Problem 2-30.

Causes	Importance of Cause	Cumulative Percentages
Understanding uses, hazards and limitations	20	20
Education and experience	5	25
Understanding instructions	20	45

Restricting access	20	65
Education and experience	5	70
Understanding uses, hazards & limitations	5	75
Safety requirements & pool access	5	80
Understanding instructions	5	85
Entry type (head or legs)	4	89
Adult supervision	4	93
Understanding instructions	3	96
Distraction	1	97
Finding out	1	98
Time to discovery	1	99
Non medics	1	100

Most Important Casual Factors:
Understanding uses, hazards and limitations
Education and Experience(2)
Understanding instructions
Restricting access
Understanding uses, hazards & limitations
Safety requirements & pool access

Problem 2-31.

Annual rate of damaging based on number of hits in a year:

$$\frac{\{(100\times 0.001)+(50\times 0.005)+(5\times 0.01)\}}{1 year} = 0.4 / year$$

Problem 2-32.

Annual rate of accident based on number of violations in 5 years:

$$\frac{\{(100\times 0.01)+(20\times 0.05)+(2\times 0.1)\}}{5 year} = 0.44 / year$$

Problem 2-33.

Case: Use construction of Highway Bridge to illustrate the use of risk register for two cases:

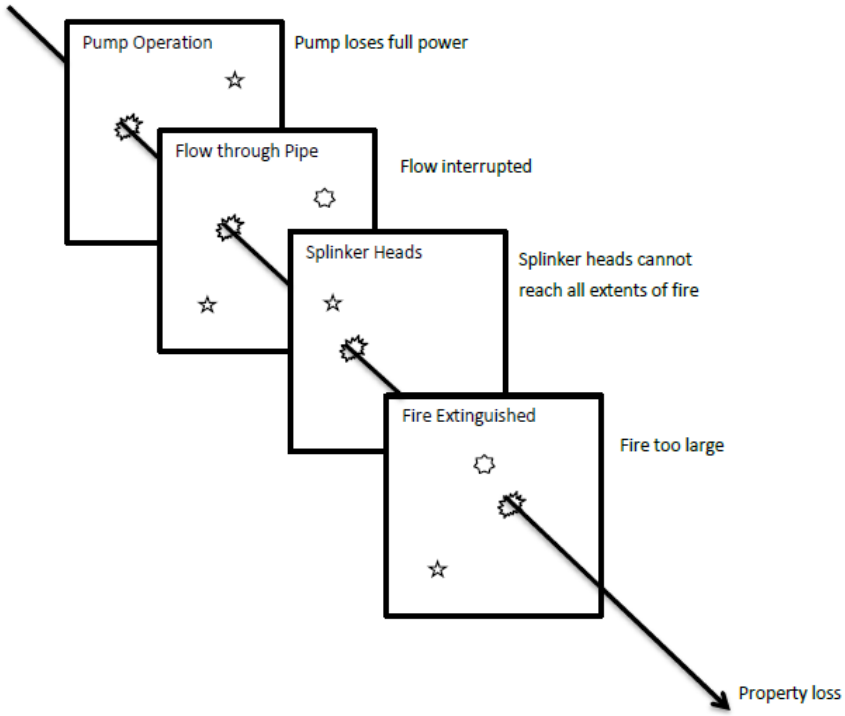
1) Identify and manage risks for human health and safety:

Risk Category	**Risk Factor or Event**	**Probability (1 to 3)**	**Impact (1 to 3)**	**Risk Score**	**Mitigation or Countermeasure**	**Contingency**	**Risk Owner**	**Action Timing**
During project: (Effect on workers)								
Labor	Long shifts	1	3	3	Monitor labor concerns and address only	Fine compliment	Project manager	Within 2 hours
Labor	Broken safety roles	2	2	4	Define HSE position, enforce labors to do safety instruction	Fine compliment	Project manager	Within 2 hours
After completing: (maintenance)								
Natural hazard	Hurricane	1	3	3	Shut down the bridge	Secure structure, equipment, and supplies	Mayor	Within 1 hour
Material	Low quality	2	3	6	Shut down the bridge, identify collapse point	Check with suppliers, repair and fix structural strengthening	Employer	Within 2 hours

2) Identify and manage risks for complete project on time and within budget:

Risk Category	**Risk Factor or Event**	**Probability (1 to 3)**	**Impact (1 to 3)**	**Risk Score**	**Mitigation or Countermeasure**	**Contingency**	**Risk Owner**	**Action Timing**
Machinery	Machine crash	2	2	4	Providing checklist and timetable to check and fix machines	Check with manufacture of machine	Support manager	Within 2 hours
Natural hazard	Snowing storm	1	2	2	Providing new timetable	Increasing labors, add another shift	Project manager	Within 2 hours
Material	Delay in arrival	2	2	4	Identify the reason of delay	Change suppliers	Supervisor	Within 2 hours
Labor	Wage	1	2	2	New contract on less	Reduction on-sire labors	Supervisor	Within 1 day

Problem 2-34.

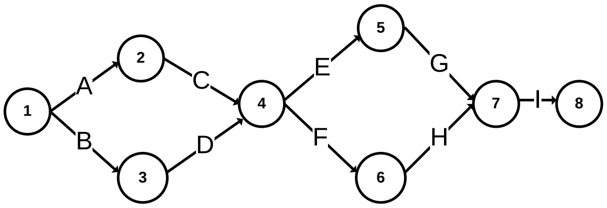


Problem 2-35.

FMEA of Sprinkler System

Sources of Risk	**Failure Mode**	**Failure Effect**	**Causes**	**Controls**	**SEV**	**OCC**	**DET**	**RPN**
Product Component: *Water Pump*	Pump doesn't operate	Fire not extinguished	Faulty pump	Periodic checks of pump	10	3	2	60
Product Component: *Water Reservoir*	Water doesn't flow through the pipes	Fire not extinguished	Insufficient reservoir or inadequate connection to reservoir	Monitor water level in reservoir	10	4	2	80
Product Component: *Sprinkler Heads*	Sprinkler heads don't divert water to the fire	Fire not extinguished	Sprinkler heads not positioned correctly	Introduce redundant sprinkler heads	8	6	5	240
External Risk: *Fire*	Fire is not extinguished	Fire not extinguished	Fire exceeds system capabilities	Increase capacity of sprinkler system	10	4	8	320

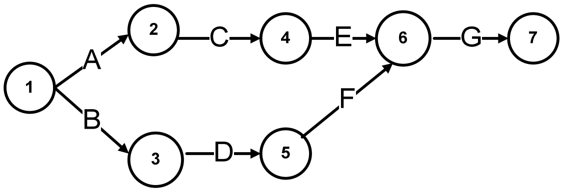
Problem 2-36.



The minimal cut sets for the above system can be presented as follows by failures of steps A to I:

(AB or CD or AD or BC) or (EF or GH or FG or EH) or I

Problem 2-37.



The minimal cut sets for the above system can be presented as follows by failures of steps A to G:

(AB or AD or AF) or (CB or CD or CF) (BC) or (EB or ED or EF) or G

Problem 2-38.

Probabilities	
P(a) =	0.01
P(b) =	0.01
P(c) =	0.01
P(d) =	0.01
P(e) =	0.01
P(f) =	0.01

Independent Sets:

P(T) = 1 - { (1 - [1-P(a)]*[1-P(b)]) * (1 - [1-P(c)]*[1-P(d)]) } * { [1-P(e)]*[1-P(f)] }
= 1 - { (1 - [1-0.01]*[1-0.01]) * (1 - [1-0.01]*[1-0.01]) } * { [1-0.01]*[1-0.01] }
= ***0.9996***

Mutually Exclusive Sets:

P(T) = [(P(a) + P(b)) + (P(c) + P(d))] * [P(e) + P(f)]
= ((0.01 + 0.01) + (0.01 + 0.01)) * (0.01 + 0.01)
= ***0.0008***

Problem 2-39.

For Independent Sets:

P (T) =1-(1-0.01)*(1-0.01)*(1-0.01*0.01)*(1-0.01*0.01)*(1-0.01)*(1-0.01) = 0**.0396**

For Mutually Exclusive Sets:

P (T) =0.01+0.01+0.01*0.01+0.01*0.01+0.01+0.01= 0**.0402**

Problem 2-40.

Probabilities	
P(a) =	0.01
P(b) =	0.01
P(c) =	0.01
P(d) =	0.01
P(e) =	0.01
P(f) =	0.01
P(g) =	0.01
P(h) =	0.01

Independent Sets:

P(T) = 1 - {1 - (1 - [1-P(a)]*[1-P(b)]) * (1 - [1-P(c)]*[1-P(d)]) } * {1 - (1 - [1-P(e)]*[1-P(f)]) * (1 - [1-P(g)]*[1-P(h)]) }
= 1 - (1 - (1 - [1-0.01] * [1-0.01]) * (1 - [1-0.01] * [1-0.01])) * (1 - (1 - [1-0.01] * [1-0.01]) * (1 - [1-0.01] * [1-0.01]))
= ***0.0008***

Mutually Exclusive Sets:

P(T) = [(P(a) + P(b)) + (P(c) + P(d))] + [(P(e) + P(f)) + (P(g) + P(h))]
= ((0.01 + 0.01) + (0.01 + 0.01)) + ((0.01 + 0.01) + (0.01 + 0.01))
= ***0.0800***

Problem 2-41.

There are two ways to solve this problem given that there is an equal probability of .01 of any event to occur and that any of the events must occur for the top event to happen:

Assuming independent sets:							
P(T)=	1-[1-P(A)][1-P(B)][1-P(C)][1-P(D)][1-P(E)][1-P(F)][1-P(G)][1-P(H)]						
	0.077255						
Assuming mutually exclusive sets:							
P(T)=	P(A)+P(B)+P(C)+P(D)+P(E)+P(F)+P(G)+P(H)						
	0.08						

Problem 2-42.

Probabilities	
P(a) =	0.01
P(b) =	0.01
P(c) =	0.01
P(d) =	0.02
P(e) =	0.03
P(f) =	0.03

Independent Sets:

P(T) = 1 - { (1 - [1-P(a)]*[1-P(b)]) * (1 - [1-P(c)]*[1-P(d)]) } * { [1-P(e)]*[1-P(f)] }
= 1 - { (1 - [1-0.01]*[1-0.01]) * (1 - [1-0.01]*[1-0.02]) } * { [1-0.03]*[1-0.03] }
= ***0.9994***

Mutually Exclusive Sets:

P(T) = [(P(a) + P(b)) + (P(c) + P(d))] * [P(e) + P(f)]
= ((0.01 + 0.01) + (0.01 + 0.02)) * (0.03 + 0.03)
= ***0.0030***

Problem 2-43.
For Independent Sets:
P (T) =1-(1-0.01)*(1-0.01)*(1-0.02*0.02)*(1-0.03*0.04)*(1-0.04)*(1-0.04) = 0**.0982**
For Mutually Exclusive Sets:
P (T) =0.01+0.01+0.02*0.02+0.03*0.04+0.04+0.04= 0**.1016**

Problem 2-44.

Probabilities	
P(a) =	0.01
P(b) =	0.01
P(c) =	0.02
P(d) =	0.02
P(e) =	0.03
P(f) =	0.04
P(g) =	0.04
P(h) =	0.04

Independent Sets:

P(T) = 1 - {1 - (1 - [1-P(a)]*[1-P(b)]) * (1 - [1-P(c)]*[1-P(d)]) } * {1 - (1 - [1-P(e)]*[1-P(f)]) * (1 - [1-P(g)]*[1-P(h)]) }
= 1 - (1 - (1 - [1-0.01] * [1-0.01]) * (1 - [1-0.02] * [1-0.02])) * (1 - (1 - [1-0.03] * [1-0.04]) * (1 - [1-0.04] * [1-0.04]))
= ***0.0062***

Mutually Exclusive Sets:

P(T) = [(P(a) + P(b)) + (P(c) + P(d))] + [(P(e) + P(f)) + (P(g) + P(h))]
= ((0.01 + 0.01) + (0.02 + 0.02)) + ((0.03 + 0.04) + (0.04 + 0.04))
= ***0.2100***

Problem 2-45.
There are two ways to solve this problem given that there is a varying probability of .01 for events A and B, .02 for events C and D, .03 for event E, and, .04 for events F, G, and H and that any of the events must occur for the top event to happen:

Assuming independent sets:							
P(T)=	1-[1-P(A)][1-P(B)][1-P(C)][1-P(D)][1-P(E)][1-P(F)][1-P(G)][1-P(H)]						
	0.192192						
Assuming mutually exclusive sets:							
P(T)=	P(A)+P(B)+P(C)+P(D)+P(E)+P(F)+P(G)+P(H)						
	0.21						

Problem 2-46.
By Fussell-Vesely factor (FVF) formula (2.12) in page 58 of textbook and P(T)=0.0402 from Problem 39:

$$FVF(A) = \frac{P(A)}{P(T)} = \frac{0.01}{0.0402} = 0.248$$

$$FVF(B) = \frac{P(B)}{P(T)} = \frac{0.01}{0.0402} = 0.248$$

$$FVF(C) = \frac{P(CD)}{P(T)} = \frac{0.01 \times 0.01}{0.0402} = 0.00248$$

$$FVF(D) = \frac{P(CD)}{P(T)} = \frac{0.01 \times 0.01}{0.0402} = 0.00248$$

$$FVF(E) = \frac{P(EF)}{P(T)} = \frac{0.01 \times 0.01}{0.0402} = 0.00248$$

$$FVF(F) = \frac{P(EF)}{P(T)} = \frac{0.01 \times 0.01}{0.0402} = 0.00248$$

$$FVF(G) = \frac{P(G)}{P(T)} = \frac{0.01}{0.0402} = 0.248$$

$$FVF(H) = \frac{P(H)}{P(T)} = \frac{0.01}{0.0402} = 0.248$$

The FVF measures the contribution significance of the event in regard to the failure probability of the system. Events with large FVF, should be used to reduce the failure probability of the system by reducing their occurrence probabilities.

By Birnbaum factor (BF) formula (2.13):

$$BF(A) = \frac{P(A)}{P(A)} = \frac{0.01}{0.01} = 1 \qquad BF(E) = \frac{P(EF)}{P(E)} = \frac{0.01 \times 0.01}{0.01} = 0.01$$

$$BF(B) = \frac{P(B)}{P(B)} = \frac{0.01}{0.01} = 1 \qquad BF(F) = \frac{P(EF)}{P(F)} = \frac{0.01 \times 0.01}{0.01} = 0.01$$

$$BF(C) = \frac{P(CD)}{P(C)} = \frac{0.01 \times 0.01}{0.01} = 0.01 \qquad BF(G) = \frac{P(G)}{P(F)} = \frac{0.01}{0.01} = 1$$

$$BF(D) = \frac{P(CD)}{P(D)} = \frac{0.01 \times 0.01}{0.01} = 0.01 \qquad BF(H) = \frac{P(H)}{P(H)} = \frac{0.01}{0.01} = 1$$

The BF measures the sensitivity of the failure probability of the system to changes in the occurrence probability of the event. Events with large BF, should be used to reduce the failure probability of the system by reducing their occurrence probabilities.

Problem 2-47

The human errors and factors that cause the failure of the automobile to start can be tabulated as follows:

Failure	**Human error**	**Probability**
Battery	The user left the interior or exterior lights on for specific time which causes the battery to drain	7
Battery	Parking the automobile for extended time. (Garage time)	6
Engine	Driving the car with inadequate cooling so that the motor is damaged by excessive heat buildup.	8
Fuel Subsystem	Using improper fuel (i.e., diesel in a gasoline powered car and vice-versa), or contaminated fuel.	5
Engine	Not changing the oil regularly so that parts prematurely wear out or seize	7
Exhaust	Seal the exhaust tail pipe as an act of vandalism, which causes the exhaust not to exit the cylinder	5
Battery	Missing, damaged or cut wires	4
Fuel Subsystem	Running out of fuel	9
Ignition	Restart the engine while it is on which may burn the starter motor	3

Problem 2-48

		Second Politician	
	Strategies	S1	S2
First	S1	(100, -100)	(200, -200)

Politician	S2	(0,0)	(100, -100)

The two politicians are competing for votes and the payoff is such that one politician's gain is the loss for the other. Each cell in the table gives the payoff for various combinations of strategies followed by the politicians. Since each cell adds up to zero, it is a zero-sum game. The rational solution for each politician for a zero sum game would be to choose a strategy to maximize the minimum payoffs.

Politician 1:
Minimum payoff if S1 is chosen = 100 (instead of 200)
Minimum payoff if S2 is chosen = 0 (instead of 100)
Maximizing the payoffs Politician 1 chooses S1.

Politician 2:
Minimum payoff if S1 is chosen = 0 (instead of 100)
Minimum payoff if S2 is chosen = -100 (instead of 0)
Maximizing the payoffs Politician 2 chooses S1.

Dominant Strategy:
Politician1:
If politician2 chooses S1, then Politician1 chooses S1 for maximum payoff (100 instead of 0).
If politician2 chooses S2, then Politician1 chooses S1 for maximum payoff (200 instead of 100).
Hence S1 is the dominant strategy for politician1.

Politician2:
If politician1 chooses S1, then Politician1 chooses S1 for maximum payoff (-100 instead of -200).
If politician1 chooses S2, then Politician1 chooses S1 for maximum payoff (0 instead of –100).
Hence S1 is the dominant strategy for politician 2.

A dominant strategy equilibrium or Nash equilibrium exists if both the politicians choose the same strategy (S1).

Problem 2-49

		Second Contractor	
	Project Bidding Prices (thousands of $000)	BP1: 300	BP2: 350
First Contractor	BP1: 300	(0, 0)	(50, -20)
	BP2: 350	(-10, 40)	(20, 20)

The payoff table is not a zero-sum game because the total value in each cell is not zero.

For the first contractor, if the second chooses the BP1: 300, then he must choose the BP1: 300 (0 instead of -10). If the second chooses the BP2: 350, then he must choose the BP1: 300 (50 instead of 20).
For the second contractor, if the first chooses the BP1: 300, then he must choose the BP1: 300 too (0 instead of -20). If the first chooses the BP2: 350, then he must choose the BP1: 300 (40 instead of 20).

Given the two strategic options for each contractor, the optimal strategy for the First Contractor that minimizes losses is to choose BP1. This strategy prevents the first contractor from realizing any losses, and coincidently, can yield the highest possible winnings.

The optimal strategy for the Second Contractor that minimizes losses is also BP1. This strategy also prevents the second contractor from realizing losses and can possibly yield the highest return.

Since the optimal strategies for both contractors are the same, this represents a dominant Strategy Equilibrium.

Note: in the above, the max min criterion was used to obtain the optimal strategy for each player. The first maximum return and minimum loss for each player occurs when either chooses BP1. Since this is the dominant strategy and results in neither player making a profit, we have a Nash equilibrium.

Problem 2-50.
Use the structure of Table 2.25 on bilateral nuclear stability and the assumption of deadlock to develop its preference table. Discuss your results.

(a) Deadlock

		USSR	
		Disarm	**Arm**
US	**Disarm**	(3, 3)	(4, <u>1</u>)
	Arm	(<u>1</u>, 4)	(<u>2</u>, <u>2</u>)

* Underlined values are the respective conditional best preference for each player

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Problem 2-51.
Use the structure of Table 2.25 on bilateral nuclear stability and the assumption of stag hunt to develop its preference table. Discuss your results.

(a) Stag hunt

		USSR	
		Disarm	**Arm**
US	**Disarm**	(<u>1</u>, <u>1</u>)	(4, 2)

Arm	(2, 4)	(3, 3)

* Underlined values are the respective conditional best preference for each player

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Problem 2-52.
Alternative A:
Political Risk Services provides a way to assess risk that involves 16 defining factors (as shown on page 68 of the text). The method presented to analyze risk, however, utilizes a scoring scheme as opposed to a probabilistic framework. One way to assess country-specific risk (especially in comparison to other countries) is to model the 16 defining factors as individual events, with associated probabilities, and consider the overarching resultant probability if these events are averaged.

$$P_{risk} = \frac{\sum_{i=1}^{16} P_{factor}}{16}$$

For example (using somewhat arbitrary ratings for probability given limited knowledge):

	Probability of Event associated with Risk Factor		
Risk Factor	**U.S.A.**	**China**	**Australia**
Turmoil	0.8	0.8	0.4
Equity Restrictions	0.2	0.7	0.2
Operations Restrictions	0.2	0.7	0.2
Taxation Discrimination	0.5	0.7	0.3
Repatriation Restrictions	0.4	0.6	0.4
Exchange Controls	0.3	0.3	0.3
Tariff Barriers	0.4	0.6	0.3
Other Important Barriers	0.4	0.4	0.4
Payment Delays	0.7	0.6	0.4
Fiscal & Monetary Expansion	0.9	0.7	0.5
Labor Policies	0.3	0.6	0.3
Foreign Debt	0.9	0.6	0.5
Investment Restrictions	0.4	0.7	0.4
Trade Restrictions	0.3	0.5	0.2
Domestic Economic Problems	0.9	0.7	0.5
International Economic Problems	0.7	0.5	0.3
Risk Event Probability	51.9%	60.6%	30.5%

Alternative B:
Using the guideline put forth by the Political Risk Services and their 17 risk components, a probabilistic framework can be used to assess country risk. By using a chart that includes the 17 categories, the specific predicted events within that category, a way of representing the impact of said event and the probability of the event occurring, one can analyze the potential risk of a country. In this way one can choose what factors are most important to defining a country as a risk. For example, the chart below shows a system of this sort that prioritizes the number of lives affected. By diagramming the probability of that the incident will occur as well as the impact that it will have one can get a grasp of the scale of risk of one country in comparison to another.

Risk Category	Event	Impact (number of people affected)	Probability of Occurring
Turmoil (18 mos.)	guerilla warfare with rebels	1,000,000	0.95
Equity Restrictions	requesting foreign investment	100,000	0.4
Operations Restrictions	military tribunal	5,000	0.6
Taxation Discrimination	no immediate	0	0
Repatriation Restrictions	no immediate	0	0
Exchange Controls	no acceptance of outside currency	6,000	0.1
Tariff Barriers	high taxes on goods from non-neighboring countries	1,000	0.01
Other Important Barriers	restricted movement of citizens	500,000	0.6
Payment Delays	inability to pay foreign dues	2,500,000	0.12
Fiscal and Monetary Expansion	no immediate	0	0
Labor Policies	labor strikes	10,000	0.05
Foreign Debt	reliance on outside countries to support war	5,000,000	0.8
Investment Restrictions	no foreseeable		
Trade Restrictions	no trade with unsupporting countries	10,000	0.7
Domestic Economic Problems	150th in the world	100,000	1
International Economic Problems	100th in the world	20,000	1
Turmoil (5 yr.)	restructuring of government	5,000,000	0.4

Alternative C:
I would propose a probabilistic framework for the prsgroup.com to assess the risk profile of a country that was as similar as possible to their scoring system that is currently in place. This is because I figure that not only are they used to their scoring system but so are the countries that use it, so if I were to dramatically change it there would be a lot of confusion and rebellion against the change. However, since probabilities tend to be less subjective than a scoring system, all of the components of their system would be based off probabilities so that the final result for the country is more accurate (at least in theory).

In order to keep it as similar as possible, I would break down the probabilistic framework the exact same way as they already have the scoring system broken down. There would still be 3 main categories: Political, Economic, and Financial. Furthermore, each category would be broken down into the same components that currently exist, 22 in all. The same goal would also be used, that being a process or framework to effectively and consistently determine a country’s stability.

The main difference would be that instead of rating each component based off a score, each component would be assigned a probability based on the aspects of that country. Then all of the components per group would be combined to determine the group's probability. The group probability for each group would be between 0 and 1, therefore, to scale each group so that they can be considered together, the probability of each group should be multiplied by the ratio of the number of components in that group by the total number of components between all three groups. For example, say the probability of political stability of a country is 0.6 or 60 percent, this would get multiplied by 12/22 since there are 12 components in the political group and 22 components overall. Finally the three group probabilities can be combined to achieve a total probability that the country is stable. Therefore, the higher the final probability of the country the better, or more likely the country is stable. Due to how this is set up, the highest possible final probability that a country could get would be 1, meaning that the country is completely stable. Since all of the country's 3 main stability groups can be assumed to be independent, the formula P(T) = P(p) + P(f) + P(e) can be used, where P(T) is the total probability of stability for that country, P(p) is the political stability probability, P(f) is the financial stability probability, and P(e) is the economical stability probability respectively.

Furthermore each component of all three groups would stay relatively the same. This makes the transition for the financial and economical groups fairly easy to calculate since they will be the old component but instead of getting a score they would get a probability based on their performance in that category. For example, would take their foreign debt percentage, take 1 minus that number and then ratio it by the number of components in the financial group. The 1 minus the probability is because we are interested in the probability of success not failure, so we want the probability that the country's foreign debt is stable.

The only group that would require more thought to change would be the political group and this is only because there are more components that are more subjectively rated compared to the other groups. Each component of the political group would be given a probability based on the country's performance in that category. For example, say the USA has a 12% chance of no corruption within its government. Then that probability would be multiplied by 1/12 (since there are 12 components in that group) and then added to the other component probabilities of that group. This will ensure that each group will get a probability between 0 and 1.

Problem 2-53.

The equation as given by Allen (1981) for probability of failure (lower bound) is as follows:

P_f= $10^{-4} * KT/n$

where:

P_f= Probability of failure

K=Factor regarding the redundancy of the structure
T=Life of the structure
n= Number of people exposed to the risk
In general, the above equation shows that the larger the consequence for an event, the less the likelihood that the event will occur. The number of population affected is inversely proportional to the probability of failure. Therefore, an increase in the number of people that will be affected the probability of failure of that event will decrease. However, the probability of failure increases with an increase in the redundancy factor and the life of the structure.

Problem 2-54.

Allen's equation (1981): $P_f = 10^{-7} \frac{TA}{W\sqrt{n}}$

Assuming a point on the line modeling Allen's equation in Fig. 2:

Prob. of failure=10^{-3}, Lives lost=10

Basic equation of a line: y=mx+b [where b=y-intercept=10^{-1}] → $P_f=10^{-3}=(10m)+10^{-1}$

$$10m = -0.099 = 10^{-7} \frac{TA}{W\sqrt{n}}$$

$$\frac{TA}{W\sqrt{n}} = -990{,}000$$

When the life of the structure or the type value (A) increases, the probability of failure also increases. On the other hand, when the redundancy (W) or number of people exposed to the risk increases, the probability of failure decreases. While a decrease in the probability of failure may seem favorable, the consequences of low-probability failures are much higher than those of their high-probability counterparts.

Problem 2-55.

Alternatives	Cost ($ Million)	Attributes as Impact Scores (0-100): Risk	Environmental Impact	Difficulty of Construction	Weighted Impact	Weighted Impact/Cost	Rank
A1	90	0	65	100	44.75	0.50	1
A2	110	100	90	0	74.5	0.68	4
A3	170	80	100	95	90.3	0.53	3
A3	60	45	0	50	30.35	0.51	2
Weight of Importance (normalized weight)	--	100 (0.43)	80 (0.35)	50 (0.22)	100 (1)	--	--

Note: Weighted Impact= (Risk x 0.43) + (Environmental Impact x 0.35) + (Difficulty of Construction x 0.22)

The best alternative, given the data shown above, is A1 as it has the lowest impact/cost ratio.

Problem 2-56.

Our example is terrorist attack happens in small town with 500000 population. We assumed four alternatives as shown below based on underlines items in table 2.35:

A1= Patrols/ Sirens/ Containment/ National Guard

A2= Ground & Airborne Sensors/ Multimedia/ Containment/ Citizens

A3= Patrols and Ground &Airborne Sensors/ Television/ Containment

A4= Patrols and Ground & Airborne Sensors/ Multimedia/ Gas Masks/ Emergency Medical Teams

Then, we assume cost values and risk reduction values and provide table below:

Alternatives	**Cost ($ Million)**	**Attributes as Impact Scores (0-100)**			**Weighted Benefit**	**Weighted Benefit/Cost**	**Rank**
		Risk	**Environmental Impact**	**Difficulty of Construction**			
A1	110.00	65.00	50.00	50.00	56.00	0.51	3
A2	140.00	70.00	90.00	70.00	77.20	0.55	2
A3	170.00	50.00	100.00	80.00	75.20	0.44	4
A4	100.00	80.00	70.00	60.00	71.60	0.72	1
Weight of importance	-	100.00	90.00	60.00	250.00	-	-
Normalized Weight	-	0.40	0.36	0.24	1.00	-	-

Problem 2-57.

Alternative	Cost ($)	Mean Risk Reduction ($1000)	Alternative success probability	Benefit ratio
A1	250	1000	0.5	2.00
A2	150	2000	0.5	6.67
A3	300	4000	0.8	10.67
A4	500	6000	1.0	12.00

Alternative 4 has the greatest benefit ratio. Although it has the highest initial cost, the benefit (mean risk reduction) is the greatest and its success rate is 100%. The alternative success probability should weigh heavily on which alternative is chosen. Alternatives 1 and 2 have only a 50% chance of succeeding, which means a 50% chance of failing. These odds are not favorable.

Problem 2-58.

Alternative	Cost ($)	Mean Risk Reduction ($1000)	Alternative Success Probability	Weighted Benefit	Weighted Benefit/Cost	Rank
A1	2000	100000	0.2	20000	10.00	4
A2	4500	200000	0.3	60000	13.33	3
A3	6000	400000	0.8	320000	53.33	2
A4	10000	600000	1	600000	60.00	1

Note: Weighted Benefit = Mean Risk Reduction x Alternative Success Probability

The “alternative success probability” was multiplied by the “mean risk reduction”, serving as a pseudo-normalizing tool when calculating the actual benefit of each alternative. This deviation from the typical weight calculation is due to the fact that the probability of success has a direct impact on the overall benefit of an action. The most beneficial alternative in this case is A4 as it has a high benefit/cost ratio and has the highest probability of success.

Problem 2-59

Referring to Problem 2-2(b), the following solution is produced:

Risk acceptance means lowering the risk down to a low enough level that it is deemed safe

System	Failure mode	Risk reduction techniques
b.1. Battery problems	The battery is damaged and might explode. The power surge from attempting to start damages other electrical components in the car	1. Specify a battery with adequate capacity for the job. 2. Use a battery designed to give other, non-catastrophic, indications that it is wearing out in order to warn the driver that their battery needs replacement before getting to this stage. 3. Install the battery in a location with adequate ventilation in order to prevent buildup of explosive hydrogen gas. 4. Warning lights or gauges to warn of a low-voltage condition in the battery, in order to enable the driver to monitor and be forewarned that there is a problem. 5. Electromechanical or logical interlocks to prevent initiating or excessively prolonging the starting sequence if there is a battery problem. 6. Redundant safety systems designed so that no single point of failure negates the safety function.

b.2. Starting subsystem risks	a. The starter and solenoid malfunction, damaging one or both of them. b. The solenoid fails to fully engage the starter against the flywheel, damaging the flywheel (which is expensive and complicated to replace)	1. Specify a starter and solenoid not only initially capable of the job, but also over the expected life of the car. 2. Electro-mechanical interlocks between the starter solenoid-starter motor-flywheel to ensure that the starter is fully engaged against the flywheel before the motor turns. 3. Placing the starter in such a way that the driver can hear a grinding sound if the starter and flywheel don’t properly engage.

		4. Redundant safety systems designed so that no single point of failure negates the safety function.
b.3. Fuel subsystem defects	The fuel system will malfunction and cause a fire or explosion. The fuel system will flood the motor, requiring either a delay or maintenance before we can start the motor again.	1. Fuel system material selection such that the materials (fuel lines, hoses, pumps, etc.) will last the expected life of the car, and endure the punishment and abuse normal driving will provide. 2. Placing the fuel system components and routing the lines such that the chance of damage, either from friction against other components or damage in an accident are minimized. 3. The fuel pump power system is set up such that a motor failure will cut power to the fuel pump (in order to prevent a fuel pump from running out-of-control, feeding fuel to an engine fire, for example). In other words, have the fuel pump fail in the OFF condition. 4. Have an anti-flood system in the engine's control computer (measuring things like fuel flow versus motor output, fuel content of the exhaust, etc). If these conditions are met, then the starter is cut off for a predetermined period of time, and an error code generated.

b.4. Ignition subsystem defects	a. The ignition timing will be off such that the motor backfires or predetonates, damaging the motor. b. An electrical fault grounds the spark but injures the operator/mechanic.	1. Have the car's computer measure enough parameters such that it can sense an abnormal condition (such as the individual cylinder's firing timing versus the crankshaft (and thus individual cylinder's piston) position. If enough errors are detected, a warning and error code are generated, and depending on the indications, the engine is set to a safe mode. 2. Select ignition system materials, and their insulating jackets, adequate for the job over the life of the car.
b.5. Engine failure modes	a. The motor is already severely damaged (such as a cracked engine block). b. The starting sequence aggravates a pre-existing condition in the motor, resulting in additional damage (such as trying to start an engine with a broken or missing timing belt/chain)	1. Have the car's computer measure enough parameters such that it can sense an abnormal condition (such as the camshaft not moving in sequence with the crankshaft.). If enough of these are detected, then a warning and error code are generated and the motor is set not to start. 2. Select materials and designs robust enough to last the life of the car.
b.6. Vandalism	The car will not start due to the vandalism. The car will not only start now, but require extensive internal repairs to overcome the damage done by the vandalism (such as sugar in the gas tank, for example)	1. Locks on the engine compartment and fuel tank filler in order to impede vandal access. 2. Motion sensitive alarms on the car to detect motion when the car is locked.

Problem 2-60
Referring to Problem 2-2(a), the recommended risk mitigation strategy for the project is presented as follows:

Risk	Strategy	Category
Product performance: Orders will not be properly picked and shipped, resulting in shortages in the retail stores.	Carefully forecast future needs, and design system to meet them. Have a performance guarantee in the contract	Risk avoidance Risk transfer
The automated systems might injure workers in the immediate vicinity to them.	Safety analysis of the design, and employee training	Risk reduction
Construction project risk: Contractor performance	Clear expectation laid out in the contract. Careful screening on contractors to ensure that they have the expertise and means to complete the project.	Risk reduction Risk reduction
Construction project risk: schedule delays	Delay penalties in the contract. Adequate time planned for the installation and troubleshooting	Risk transfer Risk reduction/absorption
Construction project risk: cost overruns	Clear specifications in the contract about what we expect the finished product to accomplish	Risk reduction/absorption
Construction project risk: economic risk	Careful financial planning Forward contracts if possible	Risk absorption Risk transfer
Construction project risk: regulatory changes		Risk absorption
The risk that existing employees would sabotage the project, staging a strike or work slowdown, or picket our stores.	Communication about the need for the project Worksite/workplace security and monitoring	Risk reduction

Problem 2-61
Use Problem 2-3(b) to outline a risk communication plan to users, i.e., operators, and automobile mechanics.

A. The best approach, obviously, is to design the risks out of the product as much as possible, both eliminating the risk as well as designing the car not to operate in an unsafe condition.

B. The next approach, for the drivers, is to provide clear active warning devices (such as lights and buzzers) to notify the driver of an unsafe condition.

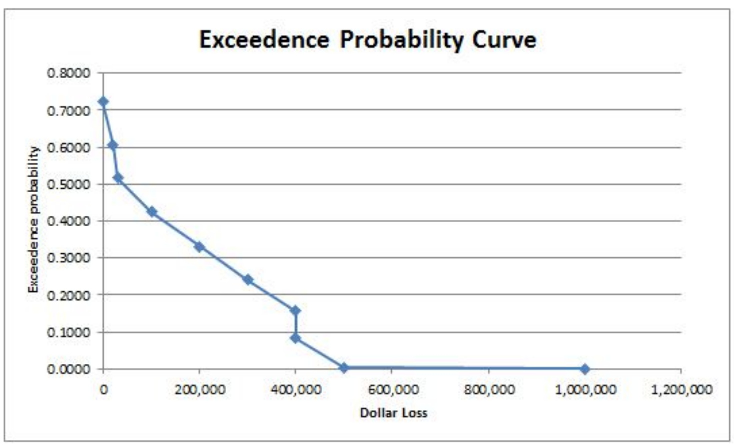
C. A distant third behind the above two is to put static plaque/signs on the car (like a warning about airbags on the back of most visors, for example), or put something in the owner's manual (which not all people read).

As far as for the mechanics, after designing the risk away, the best communication method would be through the repair manuals, as well as selected warning labels under the hood.

Problem 2-62

$$EP(L_i) = 1 - \prod_{j=1} (1 - p_i)$$

Event (Ei)	Loss (Li)	Computed Annual Probability of Occurrence (pi)	1-pi	Exceedence Probability (EP(Li))	E(L) = (pi*Li)
Event 1	1,000,000	0.001	*0.999*	*0.0010*	*1,000*
Event 2	500,000	0.002	*0.998*	*0.0030*	*1,000*
Event 3	400,000	0.080	*0.920*	*0.0828*	*32,000*
Event 4	400,000	0.080	*0.920*	*0.1561*	*32,000*
Event 5	300,000	0.100	*0.900*	*0.2405*	*30,000*
Event 6	200,000	0.120	*0.880*	*0.3317*	*24,000*
Event 7	100,000	0.140	*0.860*	*0.4252*	*14,000*
Event 8	30,000	0.160	*0.840*	*0.5172*	*4,800*
Event 9	20,000	0.180	*0.820*	*0.6041*	*3,600*
Event 10	0	0.300	*0.700*	*0.7229*	*0*

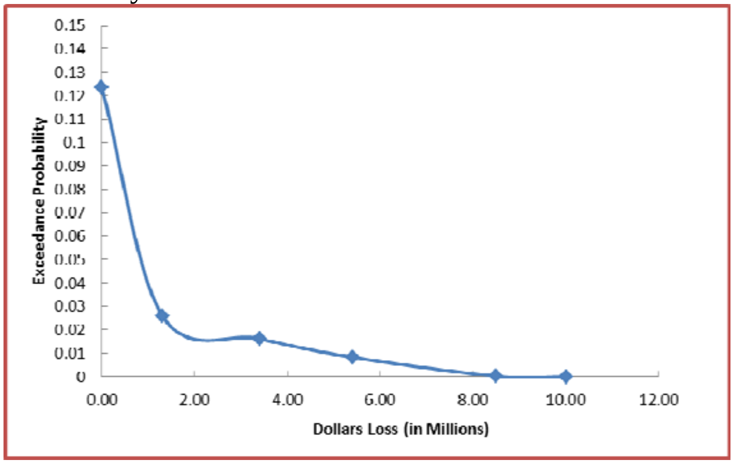


Problem 2-63

Event	Annual Probability of Occurrence (Pi)	Loss (Li)	E(L)=(pi*Li)	Exceedence Probability (EP(Li))
$Event_1$	0.0001	10,000,000.00	1,000.00	1E-04
$Event_2$	0.0002	8,500,000.00	1,700.00	0.00029998
$Event_3$	0.008	5,400,000.00	43,200.00	0.00829758

$Event_4$	0.008	3,400,000.00	27,200.00	0.0162312
$Event_5$	0.01	1,300,000.00	13,000.00	0.02606889
$Event_6$	0.1	0.00	0.00	0.123462

Probability Exceedance Curve



Problem 2-64

Event (Ei)	Loss (Li)	Computed Annual Probability of Occurrence (pi)	Exceedence Probability (EP(Li))	E(L)=(piLi)
Event 1	100,000,000	0.0002	0.0002	20000
Event 2	80,500,000	0.0004	0.00059992	32200
Event 3	50,400,000	0.001	0.00159932	50400
Event 4	30,400,000	0.009	0.010584926	273600
Event 5	10,300,000	0.012	0.022457907	123600
Event 6	100,000	0.2	0.217966326	20000

Exceedence Probability Curve: