Exam 01

**Chapters 01 and 02**

**This is an open-book, open-note test.** It will be released on Friday, 18 September at 8:00 AM. You have 10 hours in which to complete it. All exams must be submitted no later than 6:00 PM on Friday, 18 September, 2020.

**You must use the google form to submit your responses.** You can link to the form via Blackboard or by using the link which will be distributed to you via email. You are permitted one re-submit for this form. This is intended as an emergency measure, in the event that something occurs to interrupt or prevent your initial submission.

**Please keep a record of your responses:** On paper, in your Notes app, or on this exam paper if you print it out. This is your back up! While I have not experienced any issues or glitches using Google Forms, it is always a good idea to have a second (or third) record of your exam. Please do not tempt Fate. Seriously, it’s pretty obvious she’s not in a great mood these days.

**If something unexpected happens, you must notify me.** You have my email address and my mobile number (see the syllabus or any email I have sent you recently). Please use them. Do not wait until the deadline has passed before you reach out for assistance. I cannot help if I have no idea that you need help.

**Question 01**

**12 points**

List three skills that are important to have as an engineer, and provide a brief explanation for each. Please do not replicate my example below.

**Example:** An engineer should have strong math skills. Mathematical ability is obviously important for solving analytical problems, but it is also valuable for estimation and intuition. Being able to make good numeric estimates may save you time and/or money. Having an intuitive feel for numbers may give you early insight into whether a particular solution is reasonable or feasible.

An engineer should have good communication skills. Every engineer is going to find him- or herself in situations that require the ability to speak, write, and even sketch or draw clearly and effectively. You will have to be able to explain your ideas, methods, prototypes, etc. to both to your peers with similar engineering experience, and to laymen who have little or no technical knowledge.

An engineer should be creative. Whether you write code or rebuild engines, creativity makes you better able to see aspects of a problem that other people can’t, and better able to devise unique solutions to those problems. Plus, it’s fun.

An engineer must be flexible. This means you should be able to function productively within a group, or working on your own. You must be ready to throw away perfectly good work when the client changes his mind about any little thing. You must be ready to cut your budget by a third and up your deadline by two weeks. Among other things.

There are many other possibilities for this list, and many of you had great ideas and unique insights. The only place I subtracted points was if you used the same example I provided as one of your own.

**Question 02**

**12 points**

A) **6 points** Distinguish the difference between knowledge, experience, and intuition.

**Knowledge is the set of tools in your toolkit.** Math methods, physical laws, the periodic table, dates in history: these pieces of knowledge are facts that you can memorize or look up. Knowledge might expand over time (like adding new elements to the periodic table or confirming the existence of gravity waves), or change (as technica posted an article on 02/16/16 about the “death” of Moore’s law), but is not subjective (as opposed to opinion, which is subjective).

**Experience is working with those tools.** You may know how to construct an algorithm, and you may have memorized the specific language syntax, but until you have actually written the code—and it compiles and runs—you’re not yet a programmer. What seems perfectly simple when laid out in a textbook has subtlety and nuance that you will never see or understand until you actually do it (whatever “it” is).

**Intuition is grabbing the right tool to solve a problem you haven’t seen before.** Where knowledge and experience intersect, you have intuition. There’s nothing spooky or supernatural or sixth-sensey about it; intuition is your brain processing information rapidly and not entirely on a conscious level. When you are exposed to a problem or situation you have not seen before, your brain looks for patterns, and tries to reconcile them with what it already knows (knowledge, experience, or both), and sometimes your brain doesn’t tell you exactly what it’s doing, it just pops out the proper response. Then everybody thinks you’re a genius.

B) **6 points** Comment briefly but specifically on how each of these is important for developing your skills as an engineer.

**All three are critical for an engineer.** Knowledge (and not just limited to the math/science/technical stuff) and experience will both inform your overall approach to problem solving. You want knowledge for breadth, and experience for depth (you don’t need to have deep knowledge of everything). Intuition is that spark that gets you to a solution quickly, or lights up a unique new approach, or suddenly reveals how you can get a project done under time and under budget.

This answer is longer than I really expected, but again—some of you made some really interesting points here. And, just for fun:

Mal Reynolds = experience + intuition
Inara Serra = experience + intuition
Zoe Washburne = knowledge + experience
Hoban Washburne = knowledge + experience
River Tam = knowledge + intuition
Simon Tam = all knowledge
Jane Cobb = all experience
Kaylee Frye = all intuition
Shepherd Book = knowledge + experience + intuition

**Question 03**

**12 points**

In Chapter 01, we discussed Materials Engineering and Computer Engineering as examples of emerging disciplines, and noted that it has only become possible to earn degrees in these fields within the last twenty five years or so.

- **6 points** Does an engineer require a degree in a specific discipline in order to practice and participate in that discipline? Explain briefly.

**Frequently engineering disciplines overlap, and an engineer with a degree in chemical engineering might be pursuing polymer research that would be more in line with materials engineering. Or a mechanical engineer involved in human gait studies might be doing a lot of bioengineering. An electrical engineer might work exclusively**
on aviation systems. A specific degree field does not automatically dictate the type of professional path you will travel.

- **(6 POINTS)** Think about the advances in science and technology over the past decade. Can you identify any currently emerging engineering disciplines? Briefly summarize your example (it might be something that overlaps multiple disciplines, or a specialized sub-field within an existing discipline).

**Nanoengineering, mechatronics, synthetic biology, energy systems engineering:** This is just the beginning of a list. However, all of these examples are currently available with degree programs (some are graduate programs) in the US. Not many schools yet, but some prestigious institutions like MIT, University of Michigan, Stanford, Rice University.

**Question 04** (10 POINTS)

You have programmed your BOE-Bots to successfully and independently navigate both a simple closed-loop course and a more complex maze path. What real-world application can you imagine for this? What existing problem can be solved by using an autonomous, pre-programmed robot (not necessarily your BOE-Bot) capable of navigating a fixed path without real-time intervention or course correction? Briefly describe both the problem, and how a pre-programmed robot is the solution.

I can imagine a robot designed to clean skyscraper windows. This bot should be autonomous, but not free-ranging. I can also imagine a security robot designed for perimeter checks: you would want the bot to follow a precise path (and deviations would actually indicate a problem). Robots designed for order fulfillment would need to follow a fixed path: go to a specific location, retrieve the desired object, return to the original spot.

**Question 05** (54 POINTS)

On January 28, 2016, PhysOrg (https://phys.org/news/2016-01-detachable-cabin-wont-life-plane.html) reported on a Ukrainian inventor, Vladimir Tatarenko. He has unveiled a proposal for a Plane Pod (my name for it, not his), a detachable cabin for commercial airliners. The design is intended to save lives by jettisoning the passenger cabin and landing it safely on the ground, independently from the remainder of the aircraft.

1) **(4 POINTS)** What type of an engineer might this inventor be? What engineering discipline(s) would be best suited for solving this problem?

**TATARENKO IS REPORTED TO BE AN AVIATION ENGINEER.** However, any of the following disciplines would make sense: mechanical, aerospace, aeronautical. Possible, but maybe less directly related: computer, electrical, systems, materials, industrial.

2) **(5 POINTS)** Begin at the beginning: What is the problem statement? Define the problem (for which the answer is the Plane Pod) clearly and concisely.

When a commercial airliner experiences mid-flight failure of almost any kind, the result is usually catastrophic loss of life and complete destruction of the aircraft. The goal is to design and build a passenger cabin for commercial jets which can be detached in the event of emergency, and returned safely to the ground with minimum damage to the cabin and without loss of life.

3) **(12 POINTS)** If you were assembling a team to start developing this idea, who would you want? Let’s say you have infinite personnel resources (hah!) and can recruit pretty literally anyone. You do not have to name famous people (Pro Tip: Do not pick Albert Einstein, he would be a terrible choice here. In fact, you should avoid naming real humans (living or dead!), but create a dream team of four or five individuals to solve this problem. For each team member, briefly cite which engineering (or other) discipline and what specific characteristics and/or skills you are recruiting them to bring to this project.

**Aviation/Aerospace/Aeronautical Engineer:** I need a team member who has extensive knowledge and experience designing and building commercial aircraft.

**Electrical/Systems Engineer:** I need someone who has experience designing and testing complicated electrical systems, preferably in an aviation context.

**Mechanical Engineer:** Someone has to be able to figure out design of the pod, and how it couples with the existing aircraft, or how to design the chassis to which a pod can be mounted.

**Team of Technicians:** People who have experience with aircraft maintenance, repair, and servicing are essential. These people know where the potential weaknesses are.

**NTSB Failure Analysis Expert:** I want a person who has direct experience with and has deeply analyzed commercial airline disasters, and knows how a plane behaves when it fails.

**Team of Lawyers:** I will need a patent attorney to make sure that our design elements have not already been patented, to start the patent application process, or to negotiate the terms of use of existing patented components. More different lawyers for handling any liability issues!

4) **(15 POINTS)** Construct a needs hierarchy for a Plane Pod. Similar to our example in class, you should identify three top-level needs, then identify at least six additional second- and third-tier needs. Use brief, descriptive phrases (not overly-detailed explanations).

1) Interlocking Chassis System: Since a Plane Pod cannot be attached to any currently existing aircraft, an independent chassis with the cockpit, wings, jet engines, fuel tanks, cargo hold, etc. must be developed to interlock with the Pod.

2) Independent Propulsion/Landing System
   a) Active: Propulsion / navigation system to guide the pod to a safe landing place
      i) Secondary cockpit? Maybe control panel?
      ii) Secondary fuel source?
   b) Passive: Parachute or inflatable system to let the pod touch down without being damaged or destroyed

3) Sealed Cabin
   a) Pod must be water-tight in the event of a landing at sea
   b) Pod must be pressurized, and maintain pressure when it is deployed
   c) Deployed pod cannot carry excess oxygen

4) Passenger Safety
   a) Seats must have restraints
      i) More than a lap belt, but < racing harness
      ii) Auto-deploy in turbulent conditions
      iii) Giant RED button to release instantly
   b) Overhead storage should auto-lock if cabin is deployed
   c) Lavatories should auto-lock if cabin is deployed
      i) Only if empty: do not lock passengers in
      ii) Commode should self-seal and lock

Obviously this is not a comprehensive list, but it should give you an idea of a distinction between the top level and 2nd or 3rd level needs.

1) **(6 POINTS)** List and explain briefly at least two design criteria for a successful Plane Pod. (Make sure you are listing criteria, and not constraints!)

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**Exam 01: Chapters 01 and 02**

**Fall 2020**

**18 September 2020**
3) **(6 points)** Watch the inventor’s own promotional video on YouTube (https://youtu.be/ZPkr3A9DTQc). As it is presented, is this an example of good design? Support your opinion with reasons! Why do you think this invention, reported in 2016, has not taken of (pun intended)!

The idea of making catastrophic plane crashes survivable is pretty compelling, because it is always shocking when we hear about a plane crash and the number of fatalities. However, plane crashes are statistically rare, and the annual number of deaths is proportionally small (which is, I know, no comfort to anyone affected). It would seem that a better question to ask would be, “Can planes be made more safe, minimizing the chance of catastrophic failure?”

As conceived, the deceptively simple idea might make you wonder why no one’s ever done it before. But by analyzing the criteria and constraints, it should become very obvious that this is not something that could be easily (if at all) or cost-effectively retro-fitted to the existing fleet of commercial planes, which would mean scrapping existing planes and redesigning from the ground up.

Then you ask, “Why not do it anyway? How can you put a price on saving lives, you heartless monster?” Well, you do it every day, but you’re not a trillion dollar industry. Every time you do something that you know carries risk (driving too fast, driving without a seatbelt, driving in general, skiing, skydiving, skateboarding, cycling without a helmet, not wearing your mask… do I need to go on? Didn’t think so.), you are implicitly putting a price on your own life. So no, the industry isn’t operating with a malicious disregard for human life.

But an airline is a business, and, whether you like it or not, the economic reality in which we live means they can’t remain a business if they cannot make a profit. And airlines operate closer to the margins than you might think. Replacing a functional fleet of very safe planes with an untested fleet of what are purported to be ultra-safe planes is a terrible idea.

The upgraded planes might not be an upgrade at all, and the cost of a new fleet is passed on to the consumer—which means that a $200 flight to Chicago now costs $1000, with the obvious result that travelers do their own risk analysis, and come to the obvious conclusion that the $200 conventional flight is absolutely safe enough. Congratulations, now your bankrupt airline is selling that new fleet at auction for ten cents on the dollar.