UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

MIE 448F: ENGINEERING PSYCHOLOGY AND HUMAN PERFORMANCE

Final Examination, Dec. 13, 2001
(Fourth Year: Industrial Engineering; Engineering Science)
Examiner: P. Milgram; Duration: 2.5 Hours

ANSWER ANY FOUR (4) QUESTIONS
Each full question is worth 25%. (Sub-values are as indicated.)
Make sure to allocate your time accordingly (i.e. approx. 35 minutes per question).
Read each question carefully, think about it and then make sure to *answer what is asked* ...

Exam Type A: No textbooks, notes or aids (other than non-programmable calculators) may be used.
When making sketches, make sure to label all axes clearly.
It is to *everyone's* advantage for you to write *clearly, neatly and legibly!*

---

1. The following scenario is taken from page 1 of your textbook:

The driver of a modern delivery van was new at the job and not familiar with all of the features of the electronic navigation system. The screen showed him a map indicating his vehicle's location in the city, as well as colour coded locations of his different scheduled delivery sites. While on delivery on a wet, snowy evening, the traffic on the southbound highway was heavy, but moving quickly. Looking down at the north-up map on the console, the driver tried to figure out his next delivery destination, and in which direction to turn at the upcoming exit. The map was cluttered, hard to read, and upside down relative to his (southward) direction of travel. He pressed what he thought was the "zoom in" button, but immediately all destinations turned to high priority red. He glanced back at the road to check the traffic, and then looked down again to figure out where he was and what might have caused the unexpected and unusual display, which he didn't recall from the complicated instruction manual that he had studied earlier that day. Suddenly he noticed that the vehicle ahead of him had stopped. In a panic, he swerved quickly into the left lane, only to hear the blast of a truck horn from behind. Swinging back immediately to the right, he avoided collision with the stopped car in front, but, because the road was slippery, his vehicle started to skid. He lost control on the shoulder of the road and flipped the van over.

1a) 19% Discuss, in relation to the course the factors which apparently contributed to this series of events – that is, the various failures in human information processing and/or in the design of the interfaces used.

1b) 3% If the display above had been incorporated into the vehicle windscreen -- i.e. as a *heads-up display (HUD)* – do you think that the incident described above would necessarily have been prevented?

1c) 3% If the navigation display in part (a) had been supplemented with an auditory display, how do you think that it should have been implemented? Would such an auditory display likely have prevented the incident above?

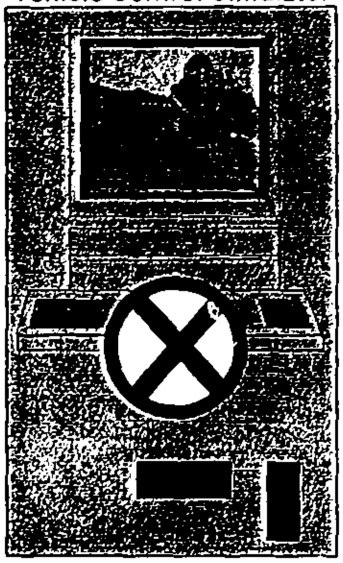
2a) 4% In the question above, while he was looking down at the navigation display, the driver (obviously) continued to drive the van. This is an example of "open loop" manual control. Using block diagrams, explain the fundamental difference between open loop and closed loop control. Give an example of each kind of control task (obviously excluding the one already given above).

2b) 5% Discuss the relationship (if any) between (simple) manual control and supervisory control.

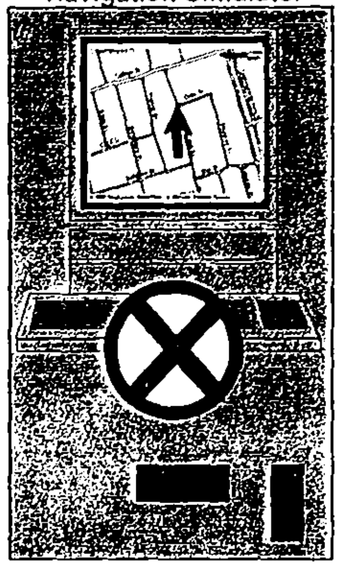
2c) 4% Taking the example of control of a super-tanker (i.e. an extremely large, slowly responding vessel), which mode of control (manual or supervisory) do you think is more appropriate? Explain your reasons.

2d) 12% Discuss the fundamental differences between designing for normal operations and designing for abnormal operations of such systems.

Vehicle Control Simulator



Navigation Simulator



3. Assume that you have been called in as a consultant for a company which is planning to market an "all purpose" automobile driving simulator. This simulator is designed for teaching both vehicle control and navigation skills.

With respect to the *vehicle control* portion, the company has mocked up the system shown at the left of the figure above. It consists of a screen, depicting a roadway scene through the front windshield, a steering wheel, an accelerator and a brake pedal, all placed at conventional locations. When used for *navigation*, the *same* simulator is used, but with a different display, as shown on the right. In this mode, it is intended to teach drivers the art of reading road maps and electronic navigation displays, and generally optimising route selection procedures, by providing them the means to "drive" a simulated vehicle - depicted here as a black arrow in the centre of the screen - through a simulated city street environment, displayed as a conventional road map. Note that, in order to reduce costs, the company has elected to use the *same* controls for both functional modes. This means, in other words, that the driver would use the same steering wheel control, as shown, also for manoeuvring through the simulated map display on the right.

3a) With respect to the objective of finding one's way to a desired goal location, discuss the fundamental
5% differences between using the left hand and the right hand displays.

3b) In the right hand figure, the black arrow icon shown in the centre of the navigation simulator screen is
10% meant to symbolise the user's own vehicle. Which do you think would be a better policy: to have the icon move through the image under control of the user, as described above, or to have the map move while the icon remains fixed in the centre of the screen? Discuss the pros and cons of each approach.

3c) One of the company's design options was to allow replacement of the steering wheel with a standard
10% 2D joystick for the navigation simulator (on the right hand side). Assume that the road map is fixed (as in the first option of part b above), and that the mapping of the joystick is *world referenced*, that is, movements of the joystick cause corresponding movements of the vehicle model. Discuss the relative pros and cons of all four cases: that is, of using the steering wheel input for the vehicle control versus using it for the navigation simulator, in comparison with using the 2D joystick for vehicle control versus using it for the navigation simulator.

4a) Discuss the criteria that should be considered when evaluating whether or not decision making is
10% "good".

4b) Discuss the requirements that one should consider in designing decision support systems for *fault*
15% *diagnosis* tasks in process control.

5a) Discuss the principal findings and the practical importance of the principles manifested in the
10% *memory* experiment which you performed in the lab, in relation to human machine systems design. (Make sure to limit yourself to discussing only those principles illustrated in the lab experiment which you performed.)

5b) In the memory experiment, many people found (or should have found) that their performance on the
5% recall task improved when the stimulus was changed from consonants to digits towards the end of the experiment. Explain why such a result makes sense, what principle this result illustrates, and what the practical importance is (if you haven't already done so in part (a).)

5c) In many ways the memory experiment resembled the Stroop effect experiment, in the sense that the
10% subjects were forced to divide their attention over two concurrent, competing tasks. Describe the principles manifested in the Stroop phenomenon and propose a block diagram model which explicitly explains the phenomenon. Make sure to show where/how the Stroop conflict occurs in your model.

---

6. Throughout this course, much mention has been made of the examples illustrated in the *Pilot Errors* videotape. One of the important messages in that video is the tradeoff between *manual* and *automated* flight.

a) Discuss some of the general Human Factors considerations which could conceivably affect such
20% *automation* design decisions, in terms of trading off human and machine functions.

b) Staying in the domain of aviation, it is obviously very important to be able to train pilots to maintain
5% their awareness of the state of their aircraft in 3D space – e.g. location, heading, attitude, velocity, etc. Assuming that you have been hired to develop the visual displays of a CRT based flight simulator, with the requirement of simulating as well as possible the view from the cockpit during low-level flight – i.e. including various terrain features – explain what computer graphics techniques you might use for creating a realistic impression of the pilot's through-the-window 3D world. Use sketches where possible/feasible.
