UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE	:	**CEB4513 - HUMAN FACTORS FOR PROCESS SAFETY**
DATE	:	**2 AUGUST 2024 (FRIDAY)**
TIME	:	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **NINE (9)** pages in this Question Booklet including the cover page and appendix.

ii. **DOUBLE-SIDED** Question Booklet.

1. Described below are the major human activities in the establishment of the appropriate procedure following a trigger of a process alarm.

"In a steadily running plant, when an operator hears an alarm, the operator must react by means of two-step response method. The operator first recognizes the audible alarm by cancelling it. Subsequently, after obtaining the information from the display panel of the alarm system, the operator takes response action to rectify the relevant faults."

Using appropriate information given in **APPENDIX**, estimate the error probability that the operator will respond to the alarm activation. Propose way(s) to improve the operator reliability in responding to the alarm activation.

[25 marks]

2. One of the plant operator tasks is to activate the emergency cooling system during a runaway reaction. Managing a runaway reaction in an epoxidation plant is a complicated task, which generally requires high level of expertise and experience among the plant operators. The cooling system is essential to prevent thermal runaway. Prior to the activation of the emergency cooling system, the plant operator is required to closely monitor the reaction temperature profile and only can act up upon when the temperature exceeds 55°C

The operational conditions in the epoxidation plant during the runaway reaction are as follows:

i. The emergency cooling system should be activated quickly as the available time to respond is short.
ii. Absolute judgement is necessary to manage the runaway reaction, which is basically poor among the plant operators.
iii. The plant operators, at times, are not very clear with their function and responsibilities.

As an engineer, you are required to calculate human error probability for the above task. Propose suitable error reduction strategies or remedial measures considering the resources for such measure are limited.

[25 marks]

3. a. As an engineer in a pharmaceutical facility, elaborate how you utilize the theory of Antecedent-Behaviour-Consequence (ABC Model) of Operant Conditioning in improving the performance of your immediate operators/technicians with respect to process safety.

[10 marks]

b. Performance Influencing Factors (PIFs) can be described as those factors, which determine the likelihood of error or effective human performance in a chemical processing plant. Any deficiency in the quality of PIFs can maximize the adverse effects on performance. Illustrate with an example, the significance of plant operator's characteristic in ensuring optimal performance during the emergency in a chemical processing plant.

[15 marks]

4. From the incident below, explain the James Reason's concept of 4 levels of failure in Human Factors Analysis and Classification System (HFACS) **AND** construct a Swiss Cheese model for the incidents:

On 7 May 1991, at about 3.45 pm, a new fireworks product of Bright Sparkler's Company was being tested close to dried chemicals. It is believed that fire sparks and smouldering casing fragments flew in many directions, some falling on the chemicals, causing a fire. The fire spreads, causing an explosion everywhere, spreading the fire to other places and buildings. The findings from the inquiry report show that the company management breached the statutory regulations and rules of the country through the installation of the firework factory on agricultural land and operating the factory without manufacturing license on many occasions, importing the raw materials without license and exporting the fireworks products without license. The relevant authorities which had direct contact with the activities of Bright Sparkler's Company did not enforce the relevant laws and the following-up of their decisions and recommendations properly.

[25 marks]

-END OF PAPER-

APPENDIX

Human Error Probability

Description	Human Error Probability
Initiate a scheduled per shift checking or inspection function	0.001
Recognised enunciated alarm (sound and blinking legend light cancelled)	0.0001
Resumed attention to /rediscovered enunciated alarm (sound and blinking legend light cancelled)	0.95
Respond to enunciated alarm (fault/interruption rectify)	0.00001
Task carried out supervised by senior technologist	0.001
Initiate action to auditory and flashing signals from annunciators (ANNs)	0.00008
Diagnose auditory and flashing signals from ANNs	0.01
Initiate high-pressure injection (HPI)	0.0001
Turn rotary control when design violates a strong populational stereotype and operating conditions are normal	0.05
Turn rotary control when design violates a strong populational stereotype and operation is under high stress	0.5
Use written test or calibration procedures	0.05
Use written maintenance procedures	0.3
Recognise ANN to loss of feed event	0.00001
Recognise ANN to high saturation level	0.0015
Use checklist for initiation of action/task	0.01

Generic task types with an associated nominal human unreliability

Generic Categories		Nominal human unreliability (5th - 95th percentile bounds)
A	Totally unfamiliar, performed at speed with no real idea of likely consequences	0.55 (0.35 - 0.97)
B	Shift or restore system to new or original state on a single attempt without supervisor or procedure	0.26 (0.14 - 0.42)
C	Complex task requiring high level of comprehension and skill	0.16 (0.12 - 0.28)
D	Fairly simple task performed rapidly or given scant attention	0.09 (0.06 - 0.13)
E	Routine, highly practiced rapid task involving relatively low level of skill	0.02 (0.007 - 0.045)
F	Restore or shift system to original or new state following procedures, with some checking	0.003 (0.0008 - 0.0009)
G	Completely familiar, well-designed, highly practiced, routine task occurring several times per hour, performed to the highest possible standards by highly motivated, highly trained and experienced person, totally aware of implications of failure with time to correct potential error but without the benefit of significant job aids	0.0004 (0.00008 - 0.009)
H	Respond correctly to system command even when there is an augmented or automated supervisory system providing accurate interpretation of system state	0.00002 (0.000006 - 0.009)
M	Miscellaneous task for which no description can be found (Nominal 5th to 95th percentile data spreads were chosen on the basis of experience available suggesting log normality)	0.03 (0.008 - 0.11)

APPENDIX

Error producing condition that may affect task reliability.

	Error Producing Condition (EPC)	Max. predicted amount by which unreliability might change	Assessed Proportion of Effect
1	Unfamiliarity with a situation which is potentially important, but which only occurs infrequently, or which is novel	17	0.4
2	A shortage of time available for error detection and correction	11	0.1
3	A low signal-noise ratio	10	0.2
4	A means of suppressing or over-riding information or features which is too easily accessible	9	0.6
5	No means of conveying spatial and functional information to operators in a form which they can readily assimilate	8	0.8
6	A mismatch between an operator's model of the world and that imagined by the designer	8	1.0
7	No obvious means of reversing an unintended action	8	0.5
8	A channel capacity overload, particularly one caused by simultaneous presentation of non-redundant information	6	0.3
9	A need to unlearn a technique and apply one which requires the application of an opposing philosophy	6	1.0
10	The need to transfer specific knowledge from task to task without loss	5.5	0.5
11	Ambiguity in the required performance standards	5	0.5
12	A means of suppressing or over-riding information or features which is too easily accessible	4	0.4
13	A mismatch between perceived and real risk	4	0.8
14	No clear, direct, and timely confirmation/feedback of an intended action from the portion of the system over which control is exerted	4	0.1
15	Operator inexperience (e.g., a newly qualified tradesman but not an expert)	3	0.4
16	An impoverished quality of information conveyed by procedures and person-person interaction	3	0.5
17	Little or no independent checking or testing of output	3	0.8
18	A conflict between immediate and long-term objectives	2.5	0.2

APPENDIX

Error producing condition that may affect task reliability.

	Error Producing Condition (EPC)	Max. predicted amount by which unreliability might change	Assessed Proportion of Effect
19	Ambiguity in the required performance standards	2.5	0.6
20	A mismatch between the educational achievement level of an individual and the requirements of the task	2	0.8
21	An incentive to use other more dangerous procedures	2	0.4
22	Little opportunity to exercise mind and body outside the immediate confines of a job	1.8	0.5
23	Unreliable instrumentation (enough that it is noticed)	1.6	0.1
24	A need for absolute judgements which are beyond the capabilities or experience of an operator	1.6	0.6
25	Unclear allocation of function and responsibility	1.6	0.4
26	No obvious way to keep track of progress during an activity	1.4	0.3
27	A danger that finite physical capabilities will be exceeded	1.4	0.05
28	Little or no intrinsic meaning in a task	1.4	0.6
29	High level emotional stress	1.3	0.4
30	Evidence of ill-health amongst operatives especially fever	1.2	0.4
31	Low workforce morale	1.2	0.6
32	Inconsistency of meaning of displays and procedures	1.2	0.8
33	A poor or hostile environment	1.15	0.5
34	Prolonged inactivity or highly repetitious cycling of low mental workload tasks (1st half hour)	1.1	0.4
35	Disruption of normal work sleep cycles	1.1	0.6
36	Task pacing caused by the intervention of others	1.06	0.3
37	Age of personnel performing perceptual tasks	1.02	0.4
38	Additional team members over and above those necessary to perform task normally and satisfactorily (per additional team member)	1.03	0.3