KOLEJ UNIVERSITI TEKNOLOGI TUN HUSSEIN ONN

PEPERIKSAAN AKHIR SEMESTER 1

SESI 2006/2007

MATAPELAJARAN	:	KEJURUTERAAN KESELAMATAN DAN PENYELENGGARAAN
KOD MATAPELAJARAN	:	DDA 2042
KURSUS	:	2 DDA
TARIKH PEPERIKSAAN	:	NOVEMBER 2006
JANGKA MASA	:	2.5 JAM

ARAHAN :

1. JAWAB **EMPAT (4)** DARIPADA **LIMA (5)** SOALAN
2. SIMBOL YANG DIGUNAKAN MEMPUNYAI TAKRIFAN YANG LAZIM KECUALI JIKA DINYATAKAN SEBALIKNYA.
3. NYATAKAN ANDAIAN YANG DIBUAT BAGI SETIAP SOALAN.

KERTAS SOALAN INI MENGANDUNGI 12 MUKA SURAT BERCETAK

S1 (a) Terdapat tiga unit proses dalam sebuah loji. Setiap unit mempunyai FAR bernilai 0.5, 0.3 and 1.0 masing-masing.

i) Tentukan FAR keseluruhan untuk loji tersebut dengan mengandaikan pekerja terdedah kepada ketiga-tiga unit secara berterusan.

ii) Andaikan setiap unit adalah saling berjauhan dimana kemalangan di sesuatu unit tidak memberi kesan kepada unit lain. Tentukan FAR keseluruhan sekiranya pekerja menghabiskan 20% daripada masa kerja dalam unit 1, 40% dalam unit 2 dan 40% dalam unit 3.

(12 Markah)

(b) Seorang pekerja diberitahu bahawa potensi untuk beliau terbunuh adalah 1 dalam setiap 500 tahun. Adakah beliau berpuashati atau terkejut ? Berapakah FAR (andaikan waktu kerja normal) dan kematian per orang per tahun? Tentukan potensi beliau untuk terbunuh dengan mengandaikan purata, FAR = 4 bagi loji kimia tersebut.

(13 Markah)

S2. (a) Lakarkan "segi tiga api" dan terangkan maknanya.

(5 Markah)

(b) Tentukan jisim setara TNT untuk *cloud* mengandungi 12400 kg propane. Haba pembakaran piawai propane adalah 2217 kJ/mol dengan pengeluaran air. Haba pengewapan air adalah 44 kJ/mol. Andaikan kecekapan letupan adalah 3%.

diberi : $C_3H_8 + 5O_2 \longrightarrow 2CO_2 + 4H_2O$

Berat molekul Propane (M) = 44.1

(10 Markah)

(c) Untuk *cloud* di atas, tentukan tahap tekanan lampau yang dikeluarkan oleh letupan 40 m daripada pusatnya.

(10 Markah)

S3 Satu tangki keluli berkapasiti 500 gallon dibumikan diisi diesel dengan kadar aliran 25 gallon per minit melalui paip steel 1 inci *schedulled 40* (diameter dalam = 1.049 inci) dan 50 kaki panjang.

(a) Tentukan arus stream dalam paip (amps)

(b) Tentukan tenaga yang disimpan dalam paip dan tenaga terkumpul dalam tangki.

(c) Terangkan potensi bahaya dalam proses di atas.

(25 Markah)

S4 Pengurusan sebuah syarikat menerima aduan seorang pekerja perihal kualiti udara tempat kerja yang tidak sihat. Anda sebagai ahli jawatan kuasa keselamatan diberi tugas untuk menyemak aduan tersebut berdasarkan fakta. Untuk tujuan ini, diandaikan pekerja terdedah kepada satu bahan kimia beracun X dengan nilai TLV-TWA 180 ppm, TLV-STEL 260 ppm, dan TLV-C 300 ppm. Data di dalam **Jadual S4** merupakan nilai-nilai kepekatan bahan X yang diukur di tempat kerja.

Jadual S4: Data kepekatan

Masa	Kepekatan (ppm)
08:00	185
9:17	240
10:05	270
11:22	230
12:08	190
13:06	150
14:05	170
15:09	165
16:00	160
17:00	140

Selama 8 jam masa bekerja, pekerja terdedah kepada wap bahan kimia beracun ini. Dari jam 13:00 (satu tengah hari) hingga 14:00 pekerja rehat dan tidak terdedah kepada bahan kimia ini.

(a) Kira nilai dedahan TLV bahan beracun di tempat kerja selama masa bekerja.

(b) Adakah dedahan kepada bahan kimia tersebut masih boleh diterima tanpa sebarang peralatan kawalan/perlindungan?

(c) Melalui mod kemasukan yang manakah bahan beracun ini boleh membahayakan kepada pekerja?

(d) Apakah cadangan yang akan anda sampaikan kepada pihak syarikat berdasarkan hasil pengukuran ke atas bahan X ini?

(25 Markah)

S5 Air pendingin untuk pemukar haba dikawal oleh satu sistem seperti yang ditunjukkan di dalam **Rajah** S2. Aliran diukur oleh satu meter aliran, pengawal menentukan kadar aliran berdasarkan kepada kaedah kawalan tertentu, dan injap kawalan bergerak untuk memastikan kadar aliran sesuai keperluan bagi pemindah haba. Dengan kadar aliran pendingin yang sesuai dipastikan pemindah haba beroperasi dalam keadaan selamat.

Keseluruhan sistem tersebut akan gagal jika salah satu komponen gagal dan juga operator gagal mengawal injap kawalan secara manual.

(a) Kira keboleharapan (R) dan kebarangkalian kegagalan (P) bagi setiap komponen sistem dalam masa operasi 2 tahun seperti ditunjukkan di dalam **Jadual S2**

(b) Bina satu rajah pokok kegagalan bermula dengan satu peristiwa kemuncak **Kadar aliran rendah**

(c) Kira kadar kegagalan sistem

(d) Bilakah sistem di atas perlu disenggara bagi menjamin kadar aliran pendingin sentiasa berada pada kadar aliran terkawal?

Jadual S5: Kadar kegagalan komponen, μ

Komponen	**Kegagalan/tahun** μ
Injap kawalan	0.80
Pengawal	0.30
Meter aliran	1.50
Operator	0.30

(25 Markah)

S1 a) Three process units are in plant. The unit have FARs of 0.5, 0.3 and 1.0 respectivelly.

i) What is the overall FAR for the plant, assuming worker exposure to all three unit simultaneously.

ii) Assuming now that the unit far enought apart that an accident in one would not affect the workers in another. If a worker spends 20 % of his time in process area 1, 40 % in process area 2 and 40 % in process area 3. What is his overall FAR?

(12 Marks)

b) A worker is told her chances of being killed by a particular process area are 1 in every 500 years. Should the worker be satisfied or alarmed? What is the FAR (assuming normal working hours) and the deaths per person per year? What should her chances be, assuming an average chemical plant?

(13 Marks)

S2 a) Draw the "fire trianle" and explaint its significance.

(5 Marks)

b) Determine the equivalent mass of TNT for a cloud containing 12 400 kg of propane. The standard heat of combustion of propane is 2217 KJ/mol with a liquid water product. The latest heat of evaporation for water is 44 KJ/mol. Assume an explosion efficiency is 3 %.

Given : $C_3H_8 + 5O_2 \longrightarrow 2CO_2 + 4H_2O$

Propane molecular weight (M) = 44.1

(10 Marks)

c) For the above cloud find the peak overpressure produced by explosion of the cloud at 40 m from the centre of the cloud.

(10 Marks)

S3 A 500 gallons vessel steel grounded is being filled with diesel at rate of 25 gallons per minute through a grounded 1" schedulled 40 steel pipe (inside diameter = 1.049") that is 50 ft long.

a) Calculate the streaming current in the pipe (amps)

b) Calculate the energy stored in the pipe and the energy accumulated in the liquid.

c) Explain the potential hazards in the process above.

(25 Marks)

S4 The management of a indutrial plant has received a complaint about unhealthy air quality at the work place. You as the head of the safety department investigated then to approve the complaint with the facts at the work place.

You conducted the experiments and found out the data for a toxic substance X to which the employees may be exposed as follows TLV-TWA 180 ppm, TLV-STEL 260 ppm, and TLV-C 300 ppm. Data recorded are shown in **Jadual S4**.

Jadual S4: Data of concentration

Time	Concetration (ppm)
08:00	185
9:17	240
10:05	270
11:22	230
12:08	190
13:06	150
14:05	170
15:09	165
16:00	160
17:00	140

The worker takes a rest between the hours 1:00 P.M to 2:00 PM and is not exposed to the chemical during that time.

a) What is the TLV of the toxic substance.

b) Is the TLV value tolerable without any personal protective equipment?

c) Which entry mode does the substance into the body come?

d) What are your recommendations to the management after evaluating the data?

(25 Marks)

S5 The water to a heat exchanger is controlled by the system shown in **Rajah S5**. The flow is measured by a flow meter device, the controller decides on an approximate control strategy, and the control valve manipulates the flow of coolant. With a sufficient flow rate of the coolant is ensured that the heat exchanger runs in safe operation.

The entire system will fail if one of the system components fails and the operator also fails to control the control valve manually.

a) Calculate the reliability (R) and the failure probability (P) of each system component with 2 years time operation as indicated in **Jadual S5**

b) Draw a *Fault Tree* diagram with a *top event* **Low mass flow rate**

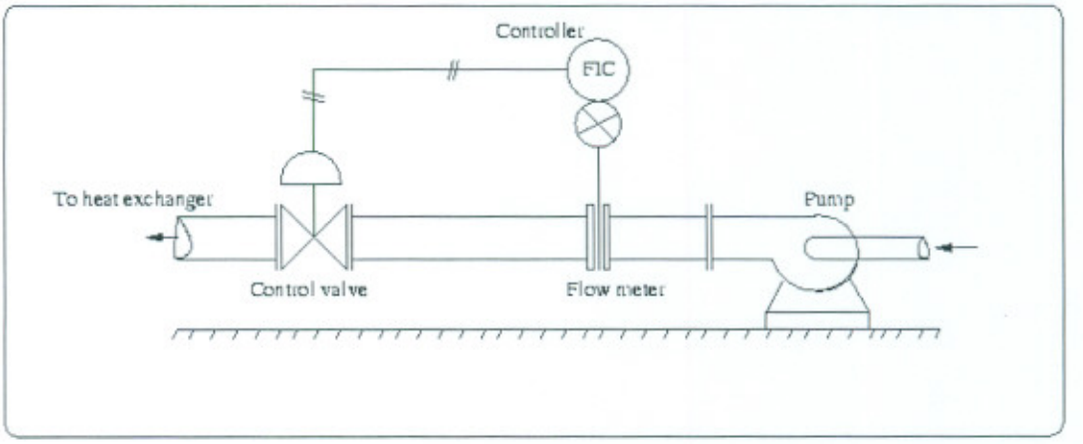
c) Calculate the failure rate of the entire system, μ

d) When should the system be maintained for the good and safe operation?

Jadual S5: Failure rate of system componens, μ

Component	**Failure/tahun** μ
Control valve	0.80
Controller	0.30
Flow meter device	1.50
Operator	0.30

(25 Marks)


Controller
FIC
To heat exchanger
Pump
Control valve
Flow meter

Rajah S5

Appendix

- Accident Statistic:
  1. Fatality Accident Rate (FAR)

$$\text{FAR} = \frac{N * 10^8 \text{ hr}}{T \text{ [hr]}} \tag{1}$$

  N : Number of fatalities [T] : Exposed Time

  2. OSHA Incident Rate

$$\text{IR}_{\text{OSHA}} = \frac{N * 2 * 10^5 \text{ hr}}{T \text{ [hr]}} \tag{2}$$

  N : Number of injuries or lost working days; [T] : Exposed Time

- Relative molecular mass of certain atoms

Table 1: Relative Molecular Mass,M

Atom	Symbol	Atomic Weight M [kg/kg-mol]
Hydrogen	H	1
Oxygen	O	16
Nitrogen	N	14
Carbon	C	12
Sulfur	S	32

- Constants and units

Name	Symbol	SI-Unit	British System Unit
gravity constant	g_c	1 (kg m/s^2)/N	32.174 ft-lb$_m$/(lb$_f$s^2)
acceleration due to gravity	g	9.81 (m/s^2)/N	32.174 ft/s^2
Universal gas constant	R_g	8.314 J/(mol K)	1545 ft lb$_f$/lb-mol °R

Explosion

- Scaled Distance:

$$z_e = \frac{r}{m_{TNT}^{1/3}} \tag{3}$$

- Scaled Overpressure:

$$p_s = \frac{p_0}{p_a} \tag{4}$$

Table 2: Unit conversion constants

Volume equivalents				
in^3	ft^3	US gal	L	m^3
1	$5.787 * 10^{-4}$	$4.329 * 10^{-3}$	$1.639 * 10^{-4}$	$1.639 * 10^{-5}$
1728	1	7.481	28.32	$2.832 * 10^{-2}$
231	0.1337	1	3.785	$3.785 * 10^{-3}$
61.03	$3.531 * 10^{-2}$	0.2642	1	$1.000*^{-3}$
$6.102 * 10^4$	35.31	264.2	1000	1

Table 3: **Data bahan mudah terbakar bagi hydrocarbon**

Material	Formula	Energy of explosion(kJ/mol)	Heat of comubustion (kJ/mol)	Flammability limit (vol.% in air)		Flash point (°C)	AIT(°C)
				Lower	Upper		
Hexane	C_6H_{14}	-4030.3	-4194.5	1.2	7.5	-230.0	487
Methane	CH_4	-818.7	-890.3	5.3	15.0	-222.5	632
Ethane	C_2H_6	-1468.7	-1599.8	3.0	12.5	-130.0	472
Propane	C_3H_8	-2110.3	-2219.9	2.2	9.5	-104.4	493
Butane	C_4H_{10}	-2750.2	-2877.5	1.9	8.5	-60.0	408
Propylene	C_3H_6	-1959.8	-2057.3	2.4	10.3	-107.8	458
Benzene	C_6H_6	-3210.3	-3301.4	1.4	7.1	-11.1	740
Toluene	C_7H_8	-3835.1	-3947.9	1.4	6.7	4.4	810
Ammonia	NH_3	-339.7	-382.6	15.0	28.0	-	651

- TNT equivalent energy = 1120 cal/g = 4686 kJ/kg. Approximation of the equivalent mass of TNT:

$$m_{TNT} = \frac{\eta m \Delta H_c}{E_{TNT}} \tag{5}$$

Static electricity

Keberaliran tentu (specific Conductivity) bagi diesel, $1/\gamma_c = 10^8$ ohm cm
pekali dielektrik, ϵ_r=25.7 ;Ketumpatan diesel, ρ=0.88 g/cm^3.
Tenaga elektrostatik:

$$J = \frac{CV^2}{2} = \frac{Q^2}{2C} \tag{6}$$

Cas terkumpul (*accumulated charge*):

$$Q = I_s t \tag{7}$$

Arus aliran elektrik I_s:

$$I_s = \left[\frac{10 * 10^{-6}\text{amp}}{(\text{m/s})^2\text{m}^2}\right](ud)^2 \tag{8}$$

Voltan akibat arus I_s dengan rintangan R:

$$V = I_s R \tag{9}$$

Halaju purata:

$$u = \dot{V}/A \tag{10}$$

Table 4: **Damage estimates for common structures based on overpressure**

Pressure		
psig	kPa	Damage
0.02	0.14	Annoying noise (139 dB)
0.03	0.21	Occasional breaking of large glass windows already under strain
0.04	0.28	Loud noise (143 dB), sonic boom, glass failure
0.1	0.69	Breakage of small windows under strain
0.15	1.03	Typical pressure for glass breakage
0.3	2.07	"safe distance" (probability 95% of no serious damage below this value); projectile limit; some damage to house ceilings, 10 % window glass broken
0.4	2.76	Limited minor structural damage
0.5-1.0	3.4 - 6.9	Large and small windows usually shatter; occational damage to window frames
0.7	4.8	Minor damage to house structur
1.0	6.9	Partial demolition of houses, made ininhabitable
1-2	6.9 - 13.8	Corrugated asbestos shatters; corrugated steel or aluminium panels; fastening fails, followed by buckling, wood panels (standard housing), fastenings fails, panels blow in
1.3	9.0	Steel frame of clad building slightly distorted
2	13.8	Partial collapse of walls and roofs of houses
2-3	13.8 - 20.7	Concrete or cinder block walls hancur
3-4	20.7 - 27.6	Frameless, self-framing steel panel building hancur, tangki penyimpan minyak pecah
5-7	34.5 - 48.2	Hampir seluruh bahagian rumah hancur
7-8	48.2 - 55.1	Gerabak kereta api bermuatan overturned
10	68.9	Bangunan rosak teruk, mata alat mesin berat (3500 kg) rosak teruk

Dimana $\dot{V}$ ialah kadar aliran isipadu.
Rintangan R [ohm]:

$$R = \frac{L}{\gamma_c A} \tag{11}$$

Table 5: Accepted eletrostatic values for Calculations

Kes	Nilai
Voltan bagi penjanaan spark diantara plat berjarak 0.01 mm	350 V
Tenaga pencucuhan minima (mJ)	
wap di udara	0.1
kabus (mists) di udara	1.0
habuk di udara	10.0
Capacitance C[10^{-12} farad]	
Tank truck (2000 gal)	1000
Capacitancy diantara dua flange 2 inci	20

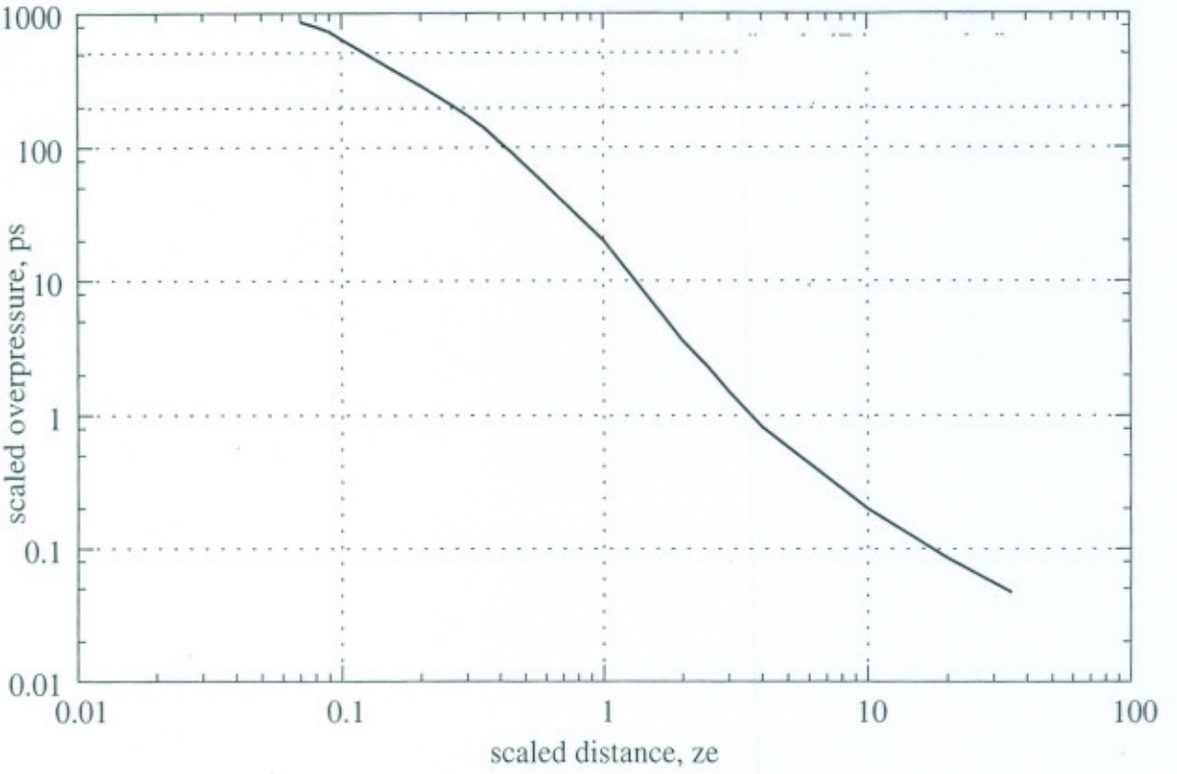


Figure 1: Scaled overpressure p_s melawan Scalled distance,z_e $(\mathrm{m/kg^{1/3}})$

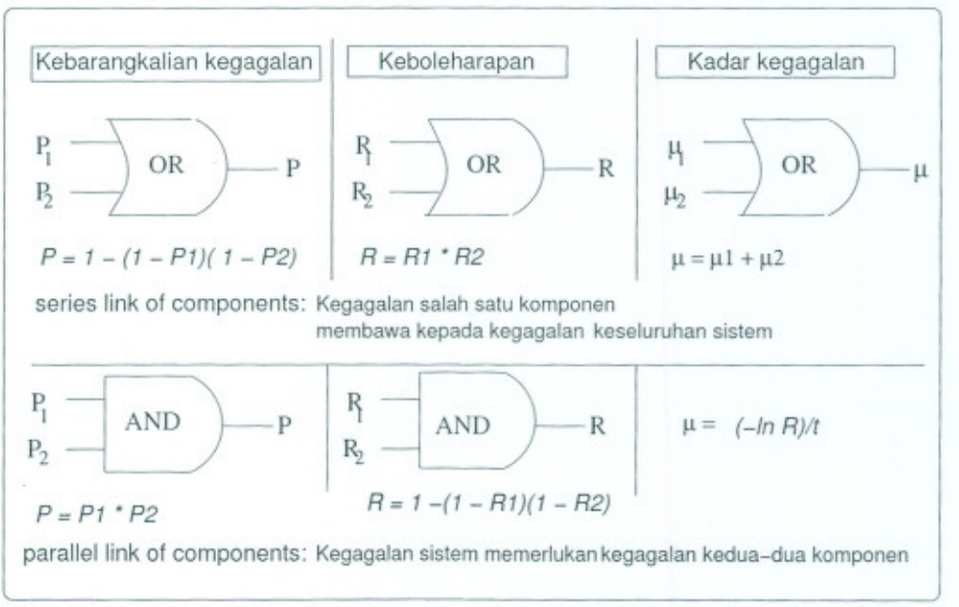


Figure 2: Logical gates