UNIVERSITI MALAYSIA PERLIS

Peperiksaan Akhir Semester Pertama
Sidang Akademik 2025/2026

Januari-Februari 2026

EMK31003 – Drives and Actuators
[*Pemandu dan Pemacu*]

Masa : 2 jam

Please make sure that this question paper has **EIGHT (8)** printed pages including this front page before you start the examination.
*[Sila pastikan kertas soalan ini mengandungi **LAPAN (8)** muka surat yang bercetak termasuk muka hadapan sebelum anda memulakan peperiksaan ini.]*

This question paper has **FOUR (4)** questions. Answer **ALL** questions Each question contributes 20 marks.
*[Kertas soalan ini mengandungi **EMPAT (4)** soalan. Jawab **SEMUA** soalan. Markah bagi tiap-tiap soalan adalah 25 markah.]*

Dicetak oleh Unit Peperiksaan & Pengijazahan, Bahagian Pengurusan Akademik, Pusat Pengurusan Akademik UniMAP

Question 1
[Soalan 1]

(a) Explain the causes of torque in an induction motor.
[Terangkan punca daya kilas dalam motor aruhan.]

(5 Marks/ *Markah*)

(b) A three phase, 40 HP, 440 V, 50 Hz, 2-pole induction motor develop a maximum torque of 250 % at slip of 10 %. Ignore the stator resistance and rotational losses.
[Sebuah motor aruhan tiga fasa, 40 HP, 440 V, 50 Hz, 2-kutub menghasilkan kilas maksimum 250 % pada gelincir 10 %. Abaikan kehilangan rintangan pemegun dan kehilangan putaran.]

i) Calculate the speed of the rotor at full load.
[Kirakan kelajuan pemutar pada beban penuh.]

(6 Marks/ *Markah*)

ii) Estimate the copper losses of the rotor.
[Kirakan kehilangan tembaga pada pemutar.]

(4 Marks/ *Markah*)

(c) A certain 5 hp three phase induction motor operates from a 440 Vrms (line to line) three phase source and draws a line current of 6.8 A rms at a power factor of 78 % lagging under rated full load condition. The full load speed is 1150 rpm. Under no load condition, the speed is 1195 rpm, and the line current is 1.2 A rms at a power factor of 30 % lagging.
[Motor aruhan tiga fasa 5 hp tertentu beroperasi dari sumber tiga fasa 440 Vrms (baris ke talian) dan menarik arus talian 6.8 A rms pada faktor kuasa 78 % ketinggalan dalam keadaan beban penuh dinilai. Kelajuan beban penuh ialah 1150 rpm. Di bawah keadaan tanpa beban, kelajuan ialah 1195 rpm, dan arus talian ialah 1.2 A rms pada faktor kuasa ketinggalan 30 %.]

i) Determine the power loss and efficiency with full load.
[Tentukan kuasa yang hilang dan kecekapan dengan beban penuh.]

(5 Marks/ *Markah*)

ii) Find the input power with no load.
[Cari kuasa masukan tanpa beban.]

(3 Marks/ *Markah*)

iii) Calculate speed regulation.
[Kirakan peraturan kelajuan.]

(2 Marks/ *Markah*)

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Question 2
[Soalan 2]

(a) A 460 V, 50 Hz, 4 poles, three phase induction motor has rated speed at full load of 1070 rpm, stator resistance of 1.5 Ω, rotor resistance referred to the stator of 1.5 Ω and equivalent winding reactance of 5.4 Ω, and the inertia of the motor is 4 Nm sec^2.
[Sebuah motor aruhan, 460 V, 50 Hz, 4 kutub, tiga fasa mempunyai kelajuan terkadar 1070 ppm pada beban penuh, rintangan pemegun 1.5 Ω, rintangan rotor dirujuk pada pemegun iaitu 1.5 Ω dan pada regangan belitan setara 5.4 Ω, dan inersia motor adalah 4 Nm saat^2.]

i) Calculate the starting time of the motor at no load and at full voltage and frequency.
[Kirakan masa permulaan motor ketika motor tiada-beban dan pada voltan penuh dan frekuensi.]
(5 Marks/ *Markah*)

ii) Assuming that the motor is unloaded and a starting resistance, R_{add} of 1 Ω is inserted in the rotor circuit, calculate the starting time of the induction machine.
[Anggapkan motor dinyahbeban dan rintangan permulaan, R_{add} daripada 1 Ω dimasukkan ke dalam litar pemutar, kirakan masa permulaan motor aruhan.]
(5 Marks/ *Markah*)

(b) A 50 hp, 60 Hz, 3-phase, wye-connected induction motor operates at full load at a speed of 1764 rpm. The rotational losses of the motor are 950 W, the stator copper losses are 1.6 kW and the iron losses are 1.2 kW.
[Motor aruhan bersambung wye 50 hp, 60 Hz, 3 fasa, beroperasi pada beban penuh pada kelajuan 1764 rpm.Kehilangan putaran motor ialah 950 W, kerugian kuprum pemegun ialah 1.6 kW dan kehilangan besi ialah 1.2 kW.]

i) Calculate the air-gap power.
[Kirakan kuasa celah-udara.]
(5 Marks/ *Markah*)

ii) Calculate the input power.
[Kirakan kuasa masukan.]
(4 Marks/ *Markah*)

iii) Compute the motor efficiency.
[Kirakan kecekapan motor.]
(3 Marks/ *Markah*)

Question 3
[Soalan 3]

(a) Explain with the help of diagram the working principle of piston compressor.
[Terangkan dengan bantuan gambar rajah prinsip kerja pemampat omboh.]

(5 Marks / *Markah*)

(b) Name and illustrate symbol for **THREE (3)** main components in FRL unit and briefly explain function of each component
*[Namakan dan gambarkan simbol untuk **TIGA (3)** komponen utama dalam unit FRL dan terangkan secara ringkas fungsi setiap komponen]*

(3 Marks / *Markah*)

(c) A double acting pneumatic cylinder has a diameter of 100 mm. The rod is 40 mm diameter, and the stroke is 120 mm. It must produce a pushing force of 12 kN. The flow rate available in both directions is 12 dm^3/minute; calculate
[Silinder pneumatik bertindak berganda mempunyai diameter 100 mm. Rod adalah diameter 40 mm dan lejang adalah 120 mm. Ia mesti menghasilkan daya tolakan 12 kN. Kadar aliran yang tersedia dalam kedua-dua arah ialah 12 dm3/minit, kirakan]

i) The system pressure needed
[Tekanan sistem yang diperlukan]

(2 Marks / *Markah*)

ii) The force retraction
[Kuasa penarikan balik]

(3 Marks / *Markah*)

iii) The velocity on the extension.
[Halaju pada pemanjangan]

(3 Marks / *Markah*)

iv) The velocity on the extraction.
[Halaju pada penarikan]

(2 Marks / *Markah*)

v) The power used on the outstroke (extension motion)
[Kuasa yang digunakan pada pukulan keluar (gerakan lanjutan)]

(2 Marks / *Markah*)

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Question 4
[Soalan 4]

(a) Compare the differences between pneumatic and hydraulic systems.
[Bandingkan perbezaan antara sistem pneumatik dan hidraulik]

(4 Marks / *Markah*)

(b) Tandem cylinder is a type of actuator in linear motion. Explains the application and the working principle of this actuator type in pneumatic system with the aid of a diagram.
[Silinder tandem ialah jenis penggerak dalam gerakan linear. Terangkan aplikasi dan prinsip kerja jenis penggerak ini dalam sistem pneumatik dengan bantuan gambarajah]

(5 Marks / *Markah*)

(c) Products are required to be transferred from lower-level conveyor to higher level conveyor using two Pneumatic Cylinders as shown in **Figure 4**. Cylinder A lifts the product on receiving it at lower level. Cylinder B shifts the product from the platform to the higher-level Conveyor. Once the product is transferred, the lifting cylinder retracts, followed by the shifting cylinder.
*[Produk dikehendaki dipindahkan dari penghantar aras rendah ke penghantar aras lebih tinggi menggunakan dua Silinder Pneumatik seperti yang ditunjukkan dalam **rajah 4**. Silinder A mengangkat produk apabila menerimanya pada aras yang lebih rendah. Silinder B mengalihkan produk dari platform ke aras yang lebih tinggi. Setelah produk dipindahkan, silinder pengangkat ditarik balik, diikuti oleh silinder peralihan]*

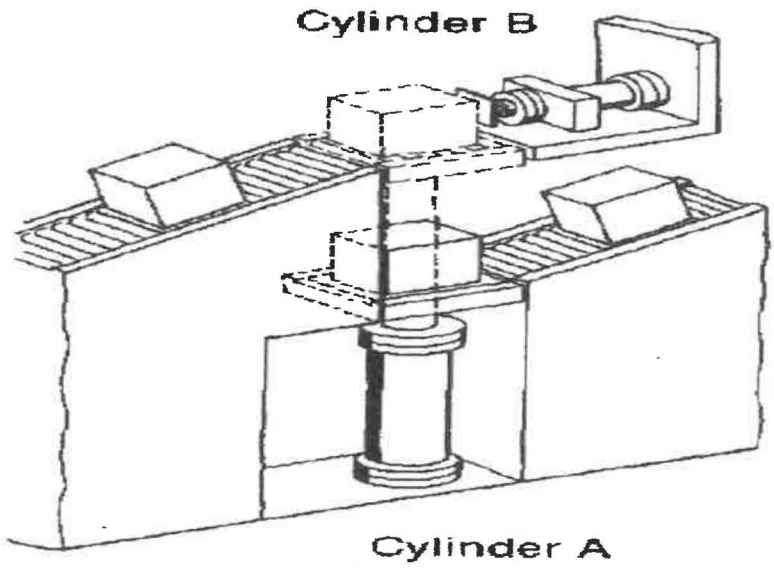

Figure 4
[Rajah 4]

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i) Show the Motion Diagram of the process.
[Tunjukkan Rajah Pergerakan proses tersebut.]

(3 Marks / *Markah*)

ii) Describe the flow of the pneumatic system with the pneumatic circuit.
[Terangkan proses sistem pnuematik tersebut dengan bantuan litar pneumatik.]

(8 Marks / *Markah*)

Appendix
[Lampiran]

AC MOTOR

$$N_{sync} = \frac{120 f_s}{P} \times rpm \qquad N_{slip} = N_{sync} - N_m \qquad T_{LOAD} = \frac{P_{out}}{\omega_m} \qquad P_{in} = \sqrt{3}\, V_L I_L \cos\theta = 3\, V_{ph} I_{ph} \cos\theta$$

$$P_{SCL} = 3\, I_1^2 R_1 \qquad P_{AG} = P_{in} - (P_{SCL} + P_{core}) = P_{conv} + P_{RCL} = 3 I_2^2 \frac{R_2}{s} = \frac{P_{RCL}}{s} \qquad P_{RCL} = 3 I_2^2 R_2$$

$$P_{conv} = P_{AG} - P_{RCL} = 3 I_2^2 \frac{R_2 (1-s)}{s} = \frac{P_{RCL}(1-s)}{s} \qquad P_{conv} = (1-s) P_{AG} \qquad P_{out} = P_{conv} - (P_{f+w} + P_{stray})$$

$$\tau_{ind} = \frac{P_{conv}}{\omega_m} = \frac{(1-s) P_{AG}}{(1-s)\omega_s}$$

PNEUMATIC AND HYDRAULIC

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$P = \rho g$$

$$V = \frac{Q_{in}}{A_P}$$

$$P = FV$$

$$P = \frac{F}{(A_p - A_r)}$$

$$V = \frac{Q_{in}}{\pi (A_p - A_r)}$$

AC MOTOR

$$I_2' = \frac{V_\phi}{\sqrt{\left(R_1 + \frac{R_2'}{s}\right)^2 + X_{eq}{}^2}} \qquad P_g = 3\left(I_2'\right)^2 \frac{R_2'}{s} = \mathrm{T_d}\,\omega_s \qquad T_d = \frac{3V^2 R_2'}{s\omega_s\left[\left(R_1 + \frac{R_2'}{s}\right)^2 + X_{eq}^2\right]}$$

$$\mathrm{T_d} = \frac{P_g}{\omega_s}$$

$$= \frac{3R_2'}{s\omega_s}\left(I_2'\right)^2$$

$$= \frac{3R_2'}{s\omega_s}\left(\frac{V_\phi}{\sqrt{\left(R_1 + \frac{R_2'}{s}\right)^2 + X_{eq}{}^2}}\right)^2 = \frac{3V_\phi{}^2 R_2'}{s\omega_s\left[\left(R_1 + \frac{R_2'}{s}\right)^2 + X_{eq}{}^2\right]}$$

$$T_d = \frac{3\,V^2 R'_2}{s\,\omega_s\,X_{eq}^2} \qquad T_s \approx \frac{3\,V^2 R'_2}{\omega_s\,X_{eq}^2} \qquad T_d \approx \frac{3\,V^2 s}{\omega_s\,R'_2} \qquad \tau = \frac{J_{eq}\omega_s}{T_{max}} \qquad S_{Max} = \frac{R'_2}{\sqrt{R^2{}_1 + X^2{}_{eq}}}$$

$$t_{st} = \frac{\tau}{2K}\left[\frac{s_1^2 - s_2^2}{2s_{max}} + s_{max} ln\frac{s_1}{s_2} + 2s_{max}(s_1 - s_2\right] \qquad T_{\max} = \frac{3\,V^2}{2\,\omega_s\left[R_1 + \sqrt{R_1^2 + X_{eq}^2}\right]}$$

$$V_{TH} = V_\phi \frac{jX_M}{R_1 + j(X_1 + X_M)} \qquad R_{TH} \approx R_1\left(\frac{X_M}{X_1 + X_M}\right)^2 \qquad X_{TH} \approx X_1$$

$$I_2 = \frac{V_{TH}}{Z_T} = \frac{V_{TH}}{\sqrt{\left(R_{TH} + \frac{R_2}{s}\right)^2 + (X_{TH} + X_2)^2}} \qquad T_{ind} = \frac{1}{\omega_s}\frac{3V_{TH}{}^2\left(\frac{R_2}{s}\right)}{\left(R_{TH} + \frac{R_2}{s}\right)^2 + \left(X_{TH} + X_2\right)^2}$$

$$S_{T\max} = \frac{R_2}{\sqrt{R_{TH}{}^2 + \left(X_{TH} + X_2\right)^2}} \qquad T_{\max} = \frac{1}{2\omega_s}\left(\frac{3V_{TH}{}^2}{R_{TH} + \sqrt{R_{TH}{}^2 + \left(X_{TH} + X_2\right)^2}}\right)$$

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