SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN AWAM

PEPERIKSAAN AKHIR

SESI II : 2024/2025

DCB40153 : AIR CONDITIONING SYSTEM TECHNOLOGY

TARIKH : 11 MEI 2025
MASA : 2.30 PETANG - 4.30 PETANG (2 JAM)

Kertas ini mengandungi **EMPAT BELAS (14)** halaman bercetak.
Bahagian A: Struktur (2 soalan)
Bahagian B: Struktur (4 soalan)

Dokumen sokongan yang disertakan : Tiada

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SECTION A : 50 MARKS
BAHAGIAN A : 50 MARKAH

INSTRUCTION:
This section consists of **TWO (2)** subjective questions. Answer **ALL** questions.

ARAHAN:
*Bahagian ini mengandungi **DUA (2)** soalan subjektif. Jawab **SEMUA** soalan.*

QUESTION 1
SOALAN 1

CLO2 (a) Identify **FIVE (5)** types of heat transfer that influence cooling loads in a room.
*Kenal pasti **LIMA (5)** jenis pemindahan haba yang mempengaruhi beban penyejukan dalam sebuah bilik.*

[5 marks]
[*5 markah*]

CLO2 (b) A fan absorbs 2 kW of power, generates a static pressure of 450 Pa, and discharges 2.5 m^3/s when the impeller angular velocity is 1300 revolutions per minute (RPM). If the impeller speed is increased to 1500 revolutions per minute, calculate the new discharge in m^3/s, the power absorbed by the fan (in kW), the static pressure (in Pa), and the percentage efficiency of the fan under the new condition.
Sebuah kipas menyerap 2 kW kuasa, menghasilkan tekanan statik sebanyak 450 Pa, dan mengalirkan 2.5 m^3/s apabila kelajuan angular pemutar adalah 1300 revolusi per minit (RPM). Jika kelajuan pemutar ditingkatkan kepada 1500 revolusi per minit, kirakan aliran baru dalam m^3/s, kuasa yang diserap oleh kipas (dalam kW), tekanan statik (dalam Pa), dan kecekapan peratus kipas dalam keadaan baharu tersebut.

[12 marks]
[*12 markah*]

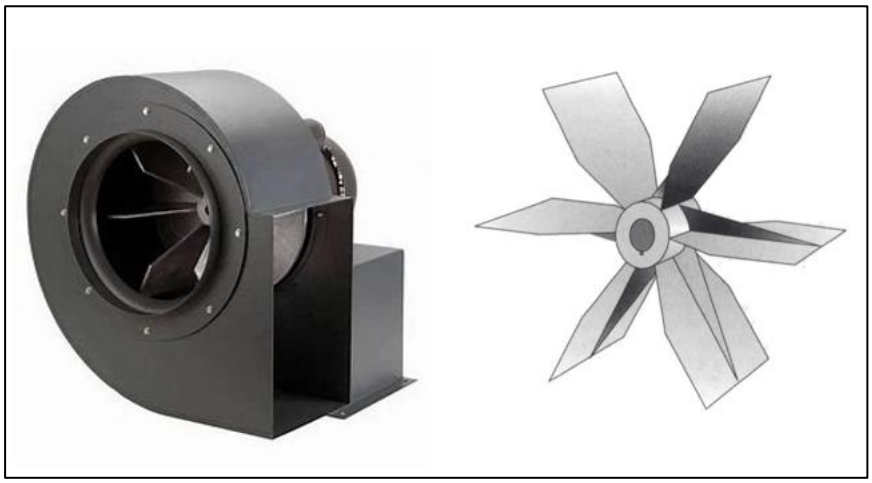


Figure A1(c) / *Rajah A1(c)*

CLO2 (c) Centrifugal fans, with their various impeller types (forward-curved, backward-curved, and radial), are used in diverse applications such as HVAC systems, dust extraction and cooling systems. The radial blade fan is a type of centrifugal fan that commonly used in the Air Conditioning Ventilation Mechanical (ACVM) system. Explain the characteristics of the radial blade fan as shown in Figure A1(c).

Kipas empar, dengan pelbagai jenis pendesaknya (melengkung ke hadapan, melengkung ke belakang dan jejari), digunakan dalam pelbagai aplikasi seperti sistem HVAC, pengekstrakan habuk dan sistem penyejukan. Kipas bilah jejari adalah sejenis kipas empar yang biasanya digunakan dalam sistem Pengudaraan dan Penyaman Udara Mekanikal (PPUM). Terangkan ciri-ciri kipas bilah jejari seperti yang ditunjukkan dalam Rajah A1(c).

[8 marks]

[*8 markah*]

QUESTION 2

SOALAN 2

CLO2 (a) Identify **FIVE (5)** psychometric processes involved in air conditioning (AHU and space).

*Kenalpasti **LIMA (5)** proses psikometrik yang terlibat dalam penyamanan udara (AHU dan ruang).*

[5 marks]

[*5 markah*]

CLO2 (b) A restaurant with dimensions of 30 m x 6 m x 3.5 m (height) will be equipped with an air conditioning system. The restaurant operates from 10:00 am to 6:00 pm. Using the provided data, determine the appropriate type of air conditioning system by referring to Table A2(a) (Appendix 1).

Sebuah restoran dengan dimensi 30 m x 6 m x 3.5 m (tinggi) akan dipasang dengan sistem penyaman udara. Restoran ini beroperasi dari 10:00 pagi hingga 6:00 petang. Menggunakan data yang diberikan, tentukan jenis sistem penyaman udara yang sesuai dengan merujuk kepada Jadual A2(a) (Lampiran 1).

Data:

Dining Chair/ *Kerusi makan*	50 people
Waiter/ *Pelayan*	5 people
Sensible heat gain per person/ *Penambahan haba deria setiap orang*	60 W
Latent heat gain per customer/ *Penambahan haba pendam setiap pelanggan*	45 W
Latent heat gain per waiter / *Penambahan haba pendam setiap pelayan*	75 W
Lighting/ *Pencahayaan*	8.2 W/m^2
Equipment sensible heat gain/ *Penambahan haba deria peralatan*	2.75 kW
Equipment latent heat gain/ *Penambahan haba pendam peralatan*	0.65 kW
Total heat flow through the walls, roof and floor/ *Jumlah aliran haba melalui dinding, bumbung dan lantai*	12 kW

Solar heat gain through glass window / *Penambahan haba solar melalui tingkap kaca*	4 kW

Cooling load factor for people & unhooded equipment/ *Faktor beban penyejukan untuk orang & peralatan tanpa tudung*: Refer Table A2(b) (Appendix 1)/ *Rujuk Jadual A2(b) (Lampiran 1)*

Cooling load factor for light/ *Faktor beban penyejukan untuk lampu*: Refer Table A2(c) (Appendix 1)/ *Rujuk Jadual A2(c) (Lampiran 1)*

[12 marks]

[*12 markah*]

CLO2 (c) As a consultant from a leading air conditioning company in Malaysia, you are tasked with selecting the appropriate type of air conditioning system for an office occupied by 25 employees. The total cumulative external heat load of the office given is 5500 watts. Based on the data provided below, determine the appropriate air conditioning system by referring to Table A2(d), (Appendix 2).

Sebagai seorang perunding daripada syarikat penghawa dingin terkemuka di Malaysia, anda diminta untuk memilih jenis sistem penghawa dingin yang sesuai bagi sebuah pejabat yang dihuni oleh 25 pekerja. Jumlah beban haba luaran kumulatif pejabat tersebut adalah 5500 watt. Berdasarkan data yang diberikan di bawah, pilih jenis sistem penghawa dingin yang sesuai dengan merujuk kepada Jadual A2(d), (Lampiran 2).

Data:

Ten 65 W fluorescent tube lights/ *Sepuluh lampu pendarfluor 65 W*

Sensible heat: 75 W per employee/ *Haba deria: 75 W setiap pekerja*

Latent heat: 55 W per employee/ *Haba pendam: 55 W setiap pekerja*

Ten unit computers with a powe consumption of 450 W / *Sepuluh unit komputer dengan penggunaan kuasa sebanyak 450 W.*

A photocopier with a power consumption of 1500 W/ *Mesin fotokopi dengan penggunaan kuasa sebanyak 1500 W*

Cooling load factor: 1/ *Faktor beban penyejukan: 1*

[8 marks]

[*8 markah*]

SECTION B : 50 MARKS
BAHAGIAN B : 50 MARKAH

INSTRUCTION:
This section consists of **FOUR (4)** subjective questions. Answer **TWO (2)** questions only.

ARAHAN:
*Bahagian ini mengandungi **EMPAT (4)** soalan subjektif. Jawab **DUA (2)** soalan sahaja.*

QUESTION 1
SOALAN 1

CLO1 (a) With the aids of a diagram, explain the process of sensible cooling in psychrometrics.
Dengan bantuan gambar rajah, terangkan proses penyejukan deria dalam psikrometrik.

[5 marks]
[*5 markah*]

CLO1 (b) Figure B1(b) shows an office that will be installed with an air conditioning system. The internal temperature of the office is 24°C while the external temperature is 33°C. By using the data given, determine the heat gain accumulated from the wall, window, door, ceiling, and floor of the office.
Rajah B1(b) menunjukkan sebuah pejabat yang akan dipasang dengan sistem penyaman udara. Suhu dalaman pejabat adalah 24°C manakala suhu luaran adalah 33°C. Dengan menggunakan data yang diberikan, tentukan beban haba yang terkumpul daripada dinding, tingkap, pintu, siling dan lantai pejabat tersebut.

Data:

U-value for the ceiling/ *Nilai U bagi siling*	3.4 W/m^2 K
U-value for the floor/ *Nilai U bagi lantai*	3.5 W/m^2 K
U-value for the door/ *Nilai U bagi pintu*	3.1 W/m^2 K
U-value for the window/ *Nilai U bagi tingkap*	3.2 W/m^2 /K
U-value for the wall / *Nilai U bagi dinding*	2.61 W/m^2 K

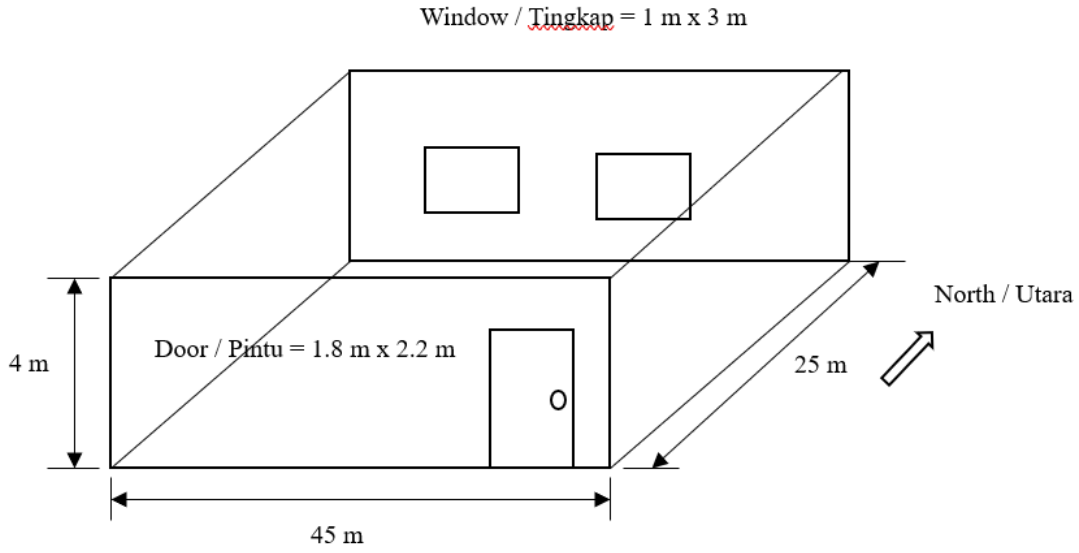


Figure B1(b)/ *Rajah B1(b)*

[12 marks]

[*12 markah*]

CLO1 (c) In a climate control system, moist air is passed through a steam-heating coil for the purpose of increasing its temperature. The air enters the coil at a dry-bulb temperature of 15°C and a wet-bulb temperature of 10°C. The airflow rate is 90 m³/min. As the air moves through the coil, steam heats the air, raising its dry-bulb temperature to 30°C. Using a CIBSE Psychometric Chart (Appendix 3), calculate the heat added to the air per minute during the heating process.

Dalam sistem kawalan iklim, udara lembap dialirkan melalui gegelung pemanas stim untuk tujuan meningkatkan suhu udara. Udara memasuki gegelung pada suhu bebuli kering sebanyak 15°C dan suhu bebuli basah sebanyak 10°C. Kadar aliran udara adalah 90 m³/min. Semasa udara bergerak melalui gegelung, stim memanaskan udara, menaikkan suhu bebuli kering kepada 30°C. Menggunakan Carta Psikometrik CIBSE (Lampiran 3), kira jumlah haba yang ditambah kepada udara setiap minit semasa proses pemanasan ini.

[8 marks]

[*8 markah*]

QUESTION 2

SOALAN 2

CLO1 (a) Describe sensible load and latent load in determining cooling load.

Huraikan beban deria dan beban pendam dalam menentukan beban penyejukan.

[5 marks]

[*5 markah*]

CLO1 (b) Figure B2(b) shows the layout of the Aman Central shopping mall, which has a height of 6 m and is in Alor Setar, Kedah. The shopping mall operates from 10 am to 10 pm. Using the following data, determine the internal heat load in kW of the shopping mall.

Rajah B2(b) menunjukkan pelan pusat membeli-belah Aman Central, yang mempunyai ketinggian 6 m dan terletak di Alor Setar, Kedah. Pusat membeli-belah ini beroperasi dari pukul 10 pagi hingga 10 malam. Menggunakan data berikut, tentukan beban haba dalaman dalam kW bagi pusat membeli-belah tersebut.

Data:

Occupancy: 200 person / *Penghuni: 200 orang*

Lighting, LPD: 18 W/ m^2 / *Pencahayaan, LPD: 18 W/m^2*

8 units freezer: 1500 W/ each / *8-unit penyejuk beku: 1500 W/ satu*

10 units refrigerated: 586 W/ each / *10-unit peti sejuk: 586 W/ satu*

Cooling load factor for people & unhooded equipment: Refer Table B2(a) (Appendix 4) / *Beban penyejukan untuk manusia & peralatan tanpa tudung: Rujuk Jadual B2(a) (Lampiran 4)*

Cooling load factor for light: Refer Table B2(b) (Appendix 4) / *Faktor beban penyejukan lampu: Rujuk Jadual B2(b) (Lampiran 4)*

Heat and moisture by human: Refer Table B2(c) (Appendix 4)/ *Haba dan kelembapan oleh manusia: Rujuk Table B2(c) (Lampiran 4)*

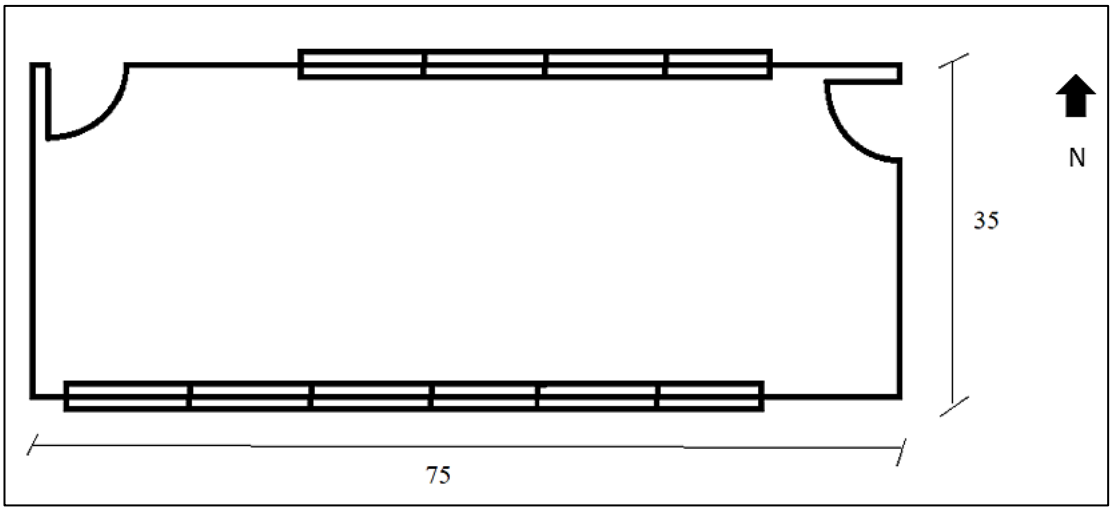


Figure B2(b) / *Rajah B2(b)*

[12 marks]

[*12 markah*]

CLO1 (c) In an air-conditioning system, 40 cubic meters of air per minute (40 m^3/min) flows through a cooling coil. The air initially has a dry-bulb temperature of 35°C and a relative humidity of 50%. To improve comfort and control humidity levels, the dry-bulb temperature of the air is reduced to 25°C through the cooling coil. Using the CIBSE Psychometric Chart (Appendix 5), calculate the heat removed from the air during this cooling process.

Dalam sistem penyaman udara, 40-meter padu udara per minit (40 m³/min) mengalir melalui gegelung penyejuk. Udara pada awalnya mempunyai suhu bebuli kering sebanyak 35°C dan kelembapan relatif sebanyak 50%. Bagi meningkatkan keselesaan dan mengawal tahap kelembapan, suhu bebuli kering udara diturunkan kepada 25°C melalui gegelung penyejuk. Menggunakan Carta Psikometrik CIBSE (Lampiran 5), kira jumlah haba yang dikeluarkan daripada udara semasa proses penyejukan ini.

[8 marks]
[*8 markah*]

QUESTION 3
SOALAN 3

CLO1 (a) Describe **FIVE (5)** types of supply devices in an HVAC (Heating, Ventilation, and Air Conditioning).
*Huraikan **LIMA (5)** jenis peranti pembekal dalam sistem HVAC (Pemanasan, Pengudaraan, dan Penyaman Udara).*

[5 marks]
[*5 markah*]

CLO1 (b) Figure B3(b) shows an air-distribution system for a lecturer's office, having flow rates as indicated. The velocity of the main duct (AB) is 8 m/s. By using the equal friction method, Chart 4.33 (Appendix 6) and Chart 4.19 (Appendix 7), determine the dimensions of rectangular ducts AB, BC, and CG. Assume the aspect ratio of rectangular ducts is 2:1.
Rajah B3(b) menunjukkan sistem pengagihan udara untuk pejabat pensyarah, mempunyai kadar aliran seperti yang ditunjukkan. Halaju sesalur utama (AB) ialah 8 m/s. Dengan menggunakan kaedah geseran sama, Carta 4.33 (Lampiran 6) dan Carta 4.19 (Lampiran 7), tentukan dimensi sesalur segiempat tepat AB, BC, dan CG.Andaikan nisbah aspek sesalur segiempat tepat ialah 2:1.

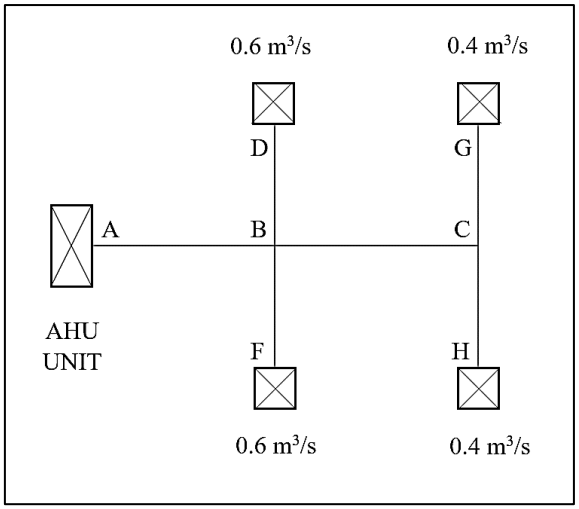


Figure B3(b) / *Rajah B3(b)*

[12 marks]

[*12 markah*]

CLO1 (c) Figure B3(c) shows a duct system with a cross-section of 0.8 m x 0.6 m, carries standard air at the rate of 720 m³/min. If the friction factor is 0.0052, calculate the pressure in the duct using D'Arcy's formula.

Rajah B3(c) menunjukkan sistem saluran udara dengan keratan rentas 0.8 m x 0.6 m, yang membawa udara standard pada kadar 720 m³/min. Jika faktor geseran adalah 0.0052, kira kejatuhan tekanan yang diperlukan pada sesalur tersebut menggunakan formula D'Arcy.

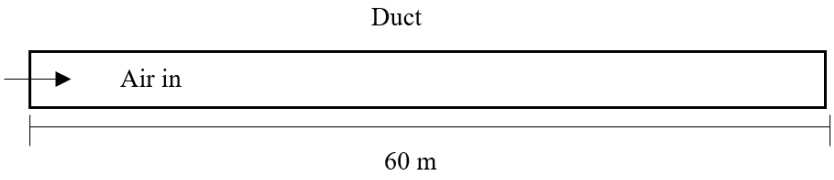


Figure B3(c)/ *Rajah B3(c)*

[8 marks]

[*8 markah*]

QUESTION 4

SOALAN 4

CLO1 (a) Identify **FIVE (5)** factors to consider when selecting the type of ducting materials for an HVAC (Heating, Ventilation, and Air Conditioning) system.
*Kenalpasti **LIMA (5)** faktor yang perlu dipertimbangkan semasa memilih jenis bahan sesalur udara untuk sistem HVAC (Pemanasan, Pengudaraan, dan Penyaman Udara).*

[5 marks]
[*5 markah*]

CLO1 (b) Figure B4(b) shows the air duct supply system for an office, with flow rates as indicated. The velocity in the main duct AB is 8 m/s. Using the Equal Friction Method and Chart 4.33 (Appendix 8), determine the diameter of ducts AB, BC, CD, BE, and CF shown in Figure B4(b).
Rajah B4(b) menunjukkan sistem saluran udara bekalan untuk sebuah pejabat, yang mempunyai kadar aliran seperti yang ditunjukkan. Halaju sesalur utama AB ialah 8 m/s. Dengan menggunakan Kaedah Geseran Sama dan Carta 4.33, (Lampiran 8), tentukan diameter sesalur AB, BC, CD, BE, dan CF yang ditunjukkan dalam Rajah B4(b).

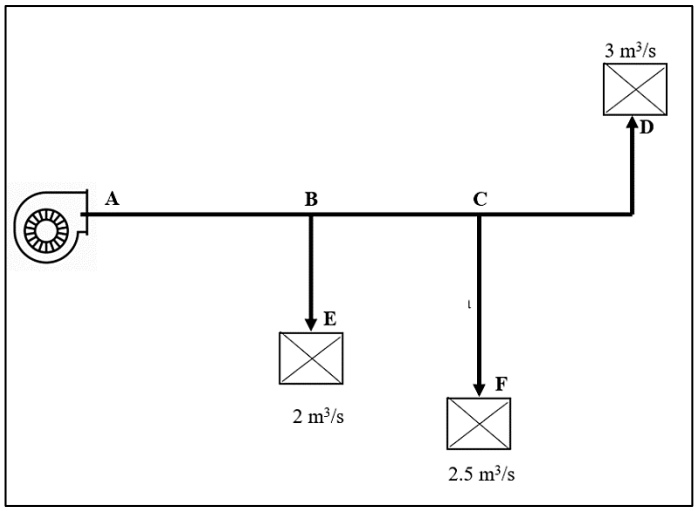


Figure B4(b) / *Rajah B4(b)*

[12 marks]
[*12 markah*]

CLO1 (c) An air-conditioning supply fan is currently operating at 600 RPM, delivering 8.9 m^3/s at standard conditions, with a static pressure of 498 Pa and requiring 4.8 kW. To accommodate a heavier air-conditioning load, the airflow needs to be increased. Using the Fan Laws, estimate the new RPM, static pressure, and power required to increase the airflow to 10.5 m^3/s.

Sebuah kipas bekalan penghawa dingin kini beroperasi pada 600 RPM, menghasilkan 8.9 m^3/s pada keadaan standard, dengan tekanan statik sebanyak 498 Pa dan memerlukan 4.8 kW. Untuk memenuhi beban penghawa dingin yang lebih berat, aliran udara perlu ditingkatkan. Menggunakan Hukum Kipas, anggarkan RPM, tekanan statik, dan kuasa baru yang diperlukan untuk meningkatkan aliran udara kepada 10.5 m^3/s.

[8 marks]

[*8 markah*]

SOALAN TAMAT

FORMULA

Q = U x A x CLTD

Q = A x SC x SCL

Q = No. of people x sensible heat gain per person x CLF

Q = No. of people x latent heat gain per person

Q = total watts x ballast factor x CLF

airflow = (volume of space x air change rate) / 3600

$Q = 0.8\ N\ V(\ m_{so} -\ m_{Sr})$

$Q = \frac{1}{3}\ N\ V(\ T_o -\ T_r)$

$Qh = m_a(\ h_2 -\ h_1)$

$Qc = m_a(\ h_1 -\ h_2)$

$SHF = \frac{SH}{SH+LH}$

$\frac{m_1}{m_2} = \frac{h_3 - h_2}{h_1 - h_3}$

$m_a = \frac{Q_a}{V_s}$

$p_f = \frac{fL}{m}(\frac{v}{4.04})^2$

$m = \frac{A}{p}$

$P = \pi D$, P = $2(a + b)$

$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$

$\frac{P_1}{P_2} = [\frac{N_1}{N_2}]^2$

$\frac{KW_1}{KW_2} = [\frac{N_1}{N_2}]^3$

efficiency $= \frac{\text{fan total pressure} \times \text{volume of flow}}{power\ absorbed} \times \frac{100}{1}$

1 tonnes = 3516.85 watts

Table A2(a) / *Jadual A2(a)*

TYPE OF EQUIPMENT	USUAL TONNAGE
Air-cooled Package	up to 15 tons
Water Cooled Package	up to 60 tons
DX Central System	30 to 120 tons
Chiller water	100 tons to above

Table A2(b) / *Jadual A2(b)* : Cooling Load Factor for people & unhooded equipment

Hours in Space	Number of Hours after Entry into Space or Equipment Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Zone Type A																							
2	0.75	0.88	0.18	0.08	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.75	0.88	0.93	0.95	0.22	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.75	0.88	0.93	0.95	0.97	0.97	0.23	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.24	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
10	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.99	0.99	0.24	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
12	0.75	0.88	0.93	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.25	0.12	0.07	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
14	0.76	0.88	0.93	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03	0.02	0.02	0.01	0.01
16	0.76	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03	0.02	0.02
18	0.77	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03

Table A2(c) / *Jadual A2(c)* : Cooling Load Factor for lights

Hours Lights On	Number of Hours after Lights Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Zone Type A																							
8 h	0.85	0.92	0.95	0.96	0.97	0.97	0.97	0.98	0.13	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10 h	0.85	0.93	0.95	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.14	0.07	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
12 h	0.86	0.93	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.14	0.07	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
14 h	0.86	0.93	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.15	0.07	0.05	0.03	0.03	0.03	0.02	0.02	0.02	0.02
16 h	0.87	0.94	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.15	0.08	0.05	0.04	0.03	0.03	0.03	0.02

Table A2(d) / *Jadual A2(d)*

SPECIFICATIONS MODEL (50Hz)			**CS-VU10UKH-1**	**CS-VU13UKH-1**	**CS-VU18UKH-1**
Cooling Capacity	(min – max)	kW	2.80 (0.84 – 3.29)	3.66 (0.92 – 4.20)	5.20 (1.10 – 5.89)
	(min – max)	Btu/h	9500 (2860 – 11200)	12500 (3140 – 14300)	17700 (3750 – 19800)

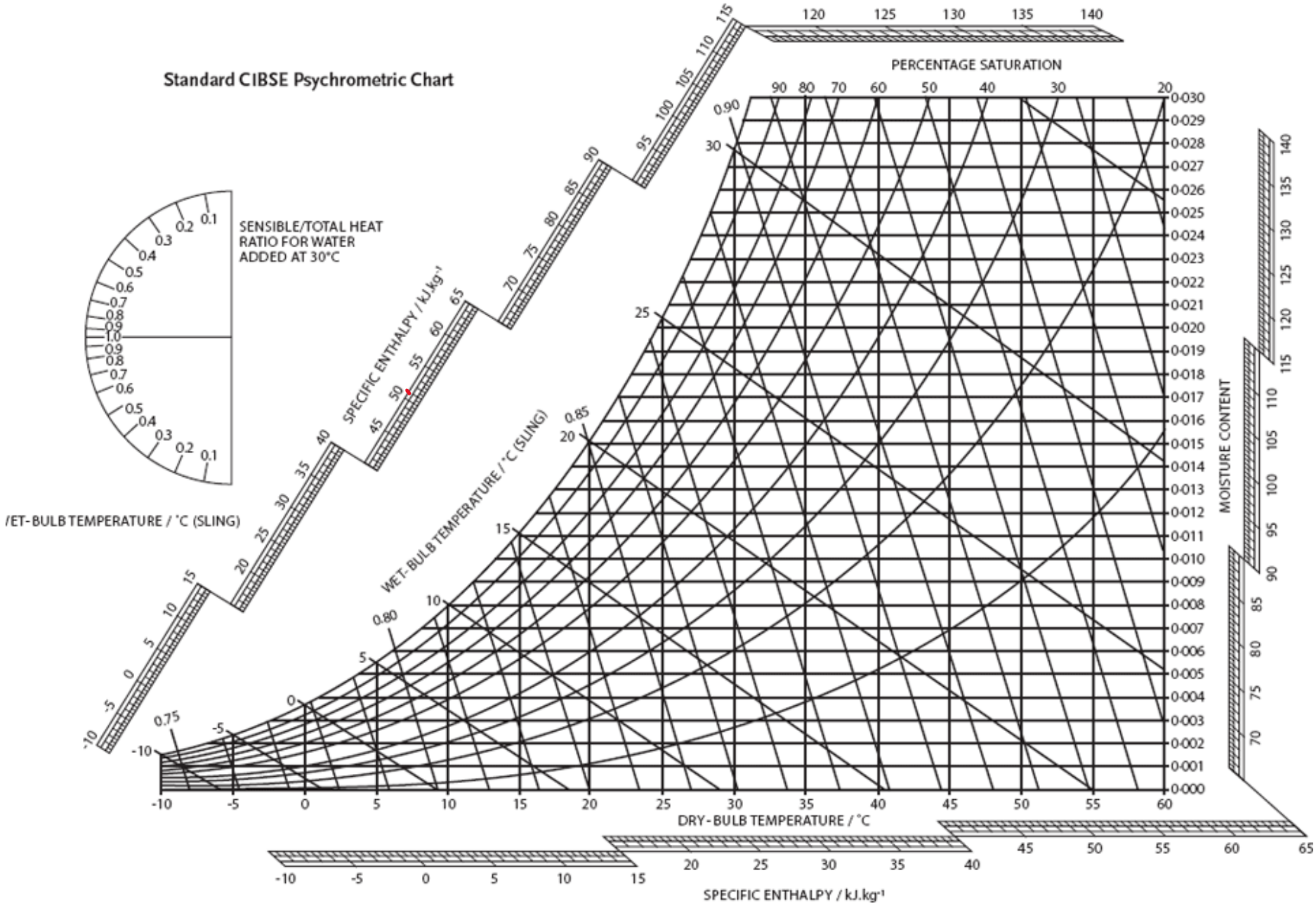

Standard CIBSE Psychrometric Chart
SENSIBLE/TOTAL HEAT RATIO FOR WATER ADDED AT 30°C
SPECIFIC ENTHALPY / KJ.kg⁻¹
WET-BULB TEMPERATURE / °C (SLING)
PERCENTAGE SATURATION
MOISTURE CONTENT
DRY-BULB TEMPERATURE / °C
SPECIFIC ENTHALPY / kJ.kg⁻¹

Table B2(a) / *Jadual A2(a)* : Cooling Load Factor for people & unhooded equipment

Hours in Space	Number of Hours after Entry into Space or Equipment Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Zone Type A																								
2	0.75	0.88	0.18	0.08	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.75	0.88	0.93	0.95	0.22	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.75	0.88	0.93	0.95	0.97	0.97	0.23	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.24	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
10	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.99	0.99	0.24	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
12	0.75	0.88	0.93	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.25	0.12	0.07	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
14	0.76	0.88	0.93	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03	0.02	0.02	0.01	0.01
16	0.76	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03	0.02	0.02
18	0.77	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.03

Table B2(b) / *Jadual B2(b)* : Cooling Load Factor for lights

Hours Lights On	Number of Hours after Lights Turned On																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Zone Type A																								
8 h	0.85	0.92	0.95	0.96	0.97	0.97	0.97	0.98	0.13	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10 h	0.85	0.93	0.95	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.14	0.07	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
12 h	0.86	0.93	0.96	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.14	0.07	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
14 h	0.86	0.93	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.15	0.07	0.05	0.03	0.03	0.03	0.02	0.02	0.02	0.02
16 h	0.87	0.94	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.15	0.08	0.05	0.04	0.03	0.03	0.03	0.02

Table B2(c) / *Jadual B2(c)* : Heat and Moisture by Human

Table 1 Representative Rates at Which Heat and Moisture Are Given Off by Human Beings in Different States of Activity

Degree of Activity		Total Heat, W: Adult Male	Total Heat, W: Adjusted, M/F[a]	Sensible Heat, W	Latent Heat, W	% Sensible Heat that is Radiant[b]: Low *V*	% Sensible Heat that is Radiant[b]: High *V*
Seated at theater	Theater, matinee	115	95	65	30		
Seated at theater, night	Theater, night	115	105	70	35	60	27
Seated, very light work	Offices, hotels, apartments	130	115	70	45		
Moderately active office work	Offices, hotels, apartments	140	130	75	55		
Standing, light work; walking	Department store; retail store	160	130	75	55	58	38
Walking, standing	Drug store, bank	160	145	75	70		
Sedentary work	Restaurant[c]	145	160	80	80		
Light bench work	Factory	235	220	80	140		
Moderate dancing	Dance hall	265	250	90	160	49	35
Walking 4.8 km/h; light machine work	Factory	295	295	110	185		
Bowling[d]	Bowling alley	440	425	170	255		
Heavy work	Factory	440	425	170	255	54	19
Heavy machine work; lifting	Factory	470	470	185	285		
Athletics	Gymnasium	585	525	210	315		

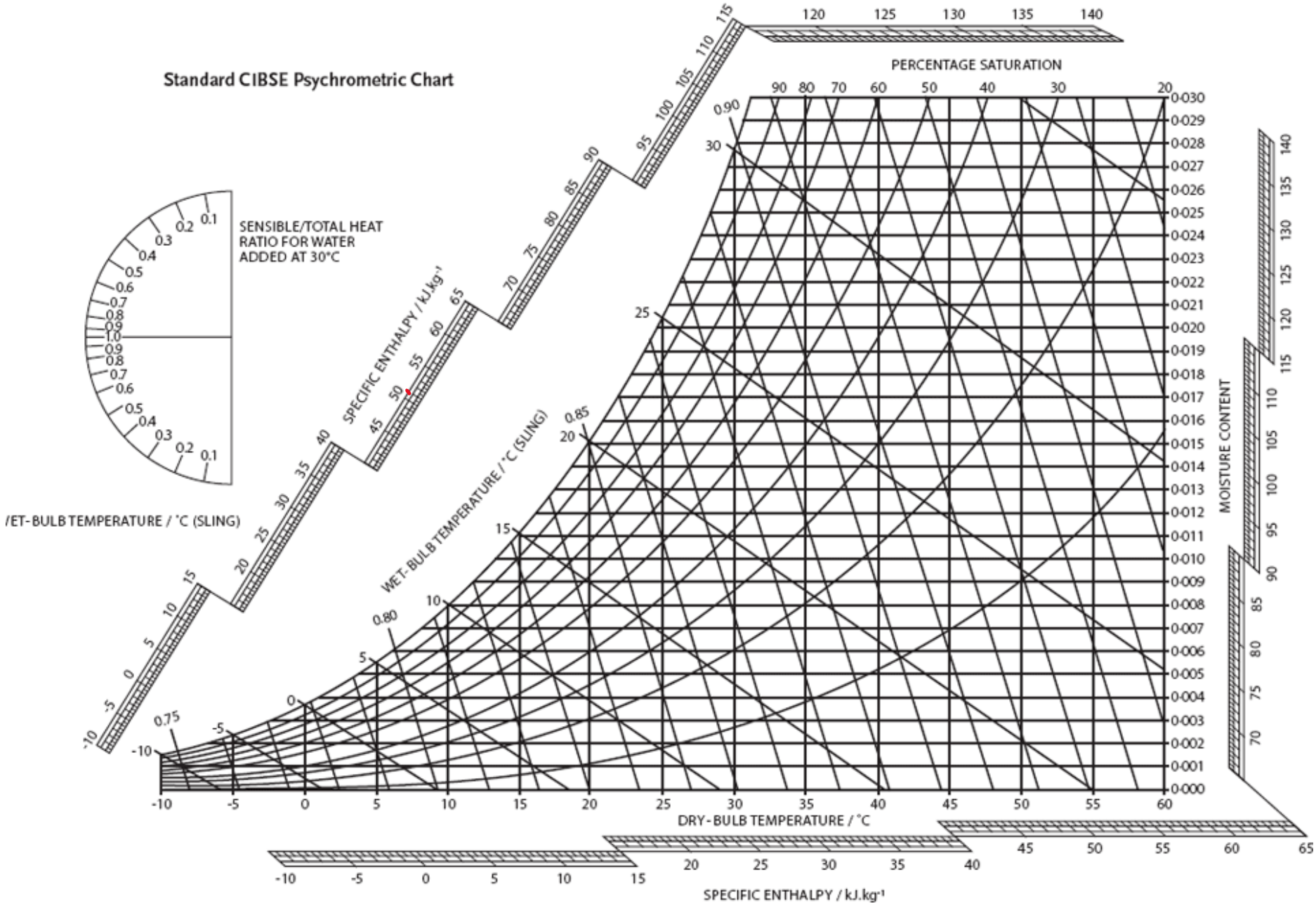
Notes:
1. Tabulated values are based on 24°C room dry-bulb temperature. For 27°C room dry bulb, total heat remains the same, but sensible heat values should be decreased by approximately 20%, and latent heat values increased accordingly.
2. Also see Table 4, Chapter 9, for additional rates of metabolic heat generation.
3. All values are rounded to nearest 5 W.

[a] Adjusted heat gain is based on normal percentage of men, women, and children for the application listed, and assumes that gain from an adult female is 85% of that for an adult male, and gain from a child is 75% of that for an adult male.

[b] Values approximated from data in Table 6, Chapter 9, where *V* is air velocity with limits shown in that table.

[c] Adjusted heat gain includes 18 W for food per individual (9 W sensible and 9 W latent).

[d] Figure one person per alley actually bowling, and all others as sitting (117 W) or standing or walking slowly (231 W).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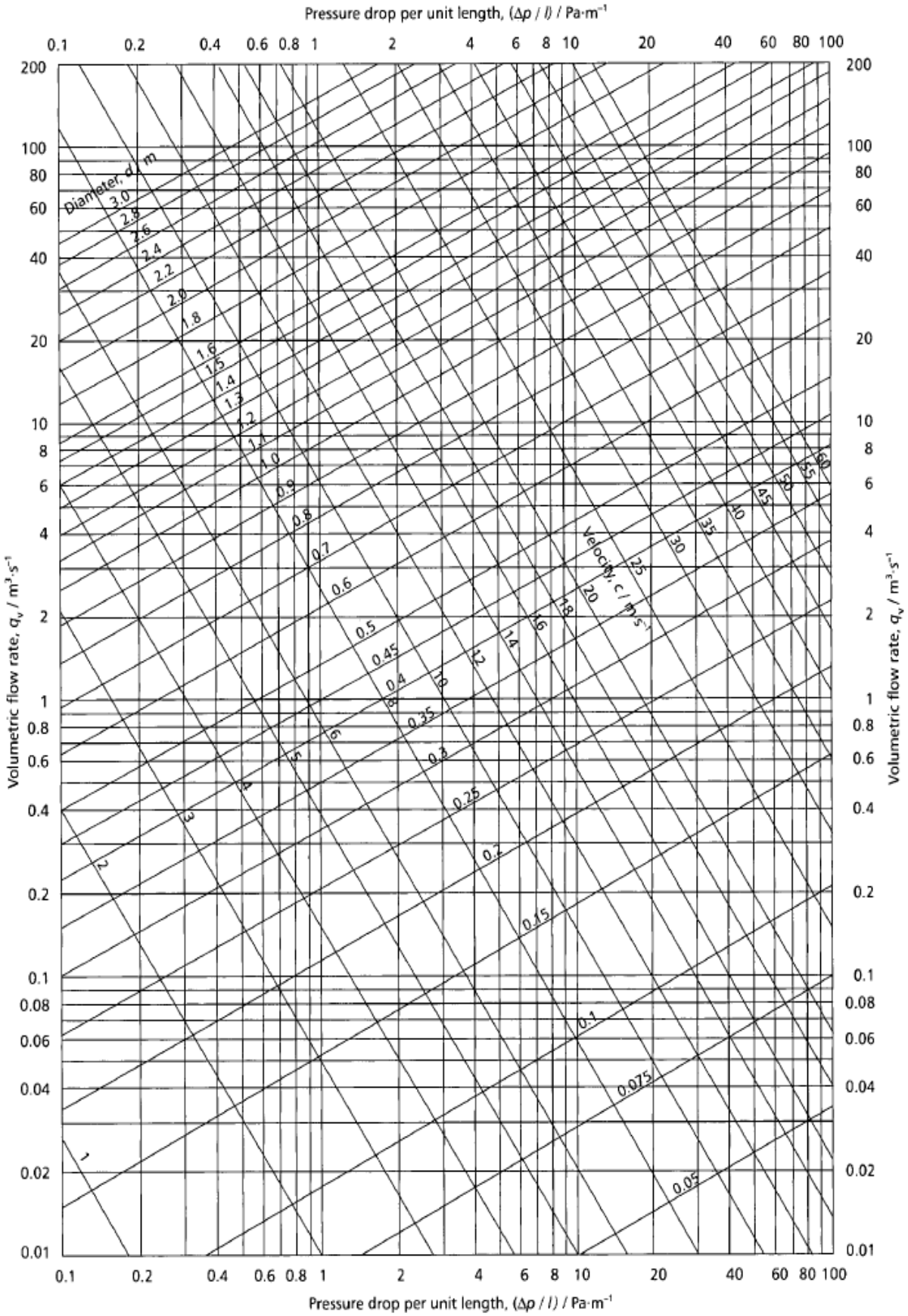
Pressure drop per unit length, (Δp / l) / Pa·m⁻¹
Volumetric flow rate, q_v / m³·s⁻¹
Diameter, d / m
Velocity, c / m·s⁻¹

CHART 4.33

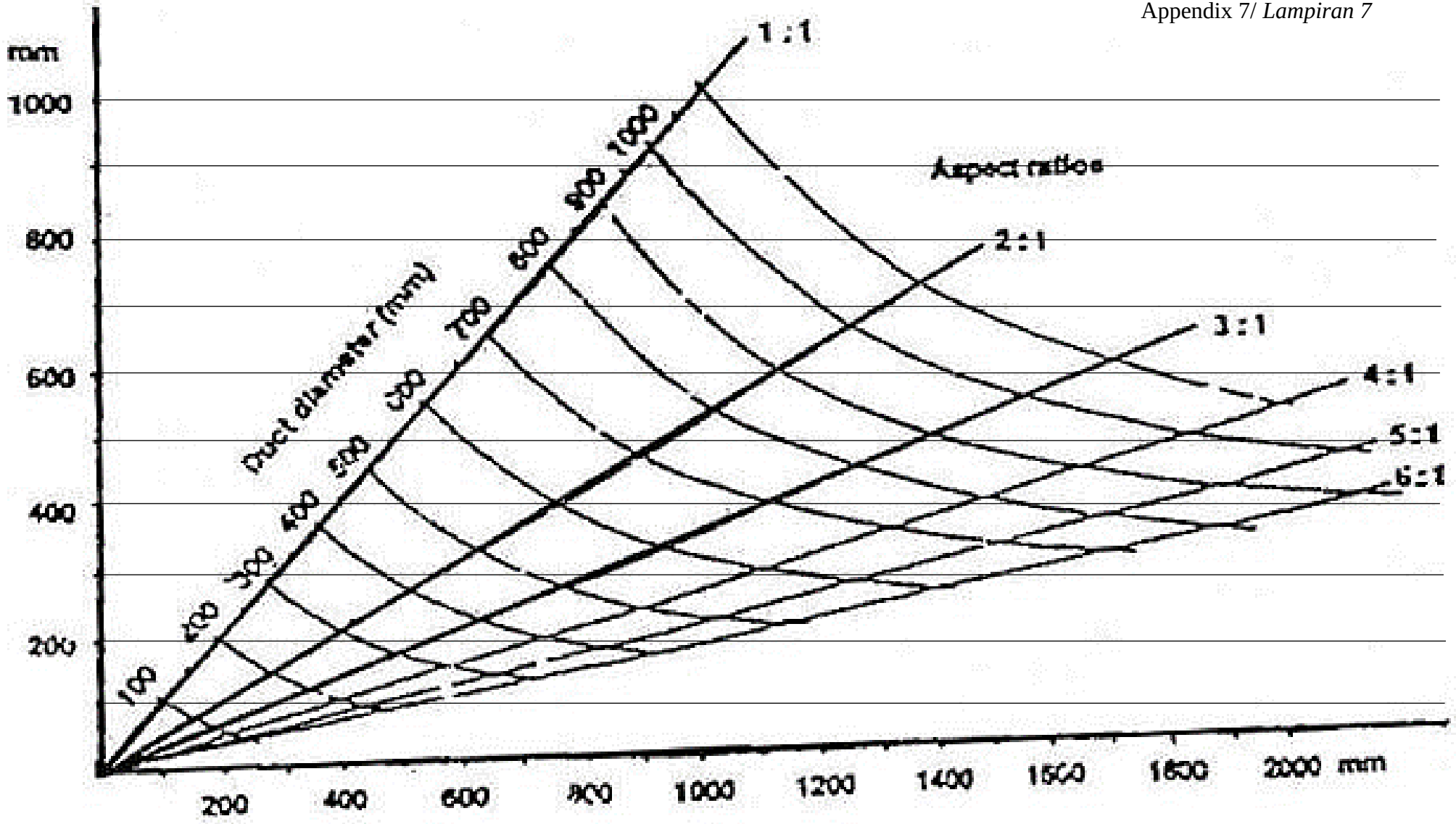

Chart 4.19: Circular to Rectangular Ductwork Conversion Chart

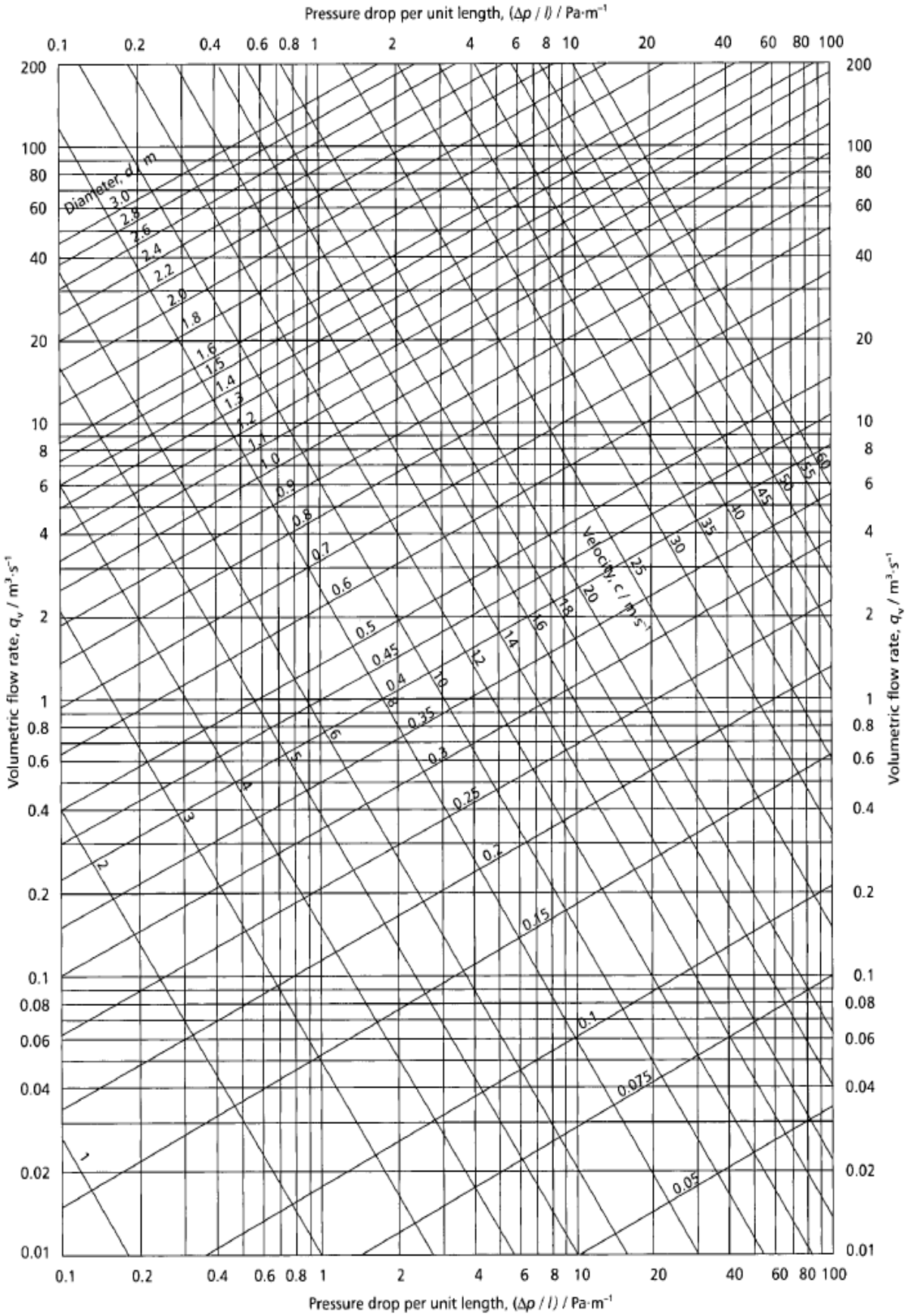
Pressure drop per unit length, (Δp / l) / Pa·m⁻¹
Volumetric flow rate, q_v / m³·s⁻¹
Diameter, d / m
Velocity, c / m·s⁻¹

CHART 4.33