The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4434 Electrical Installations**
Academic Year	: 2021/2022
Date	: 01st February 2023
Time	: 0930-1230 hrs
Duration	: **3 hours**

General Instructions

1. This question paper consists of two sections, **Section A** and **Section B** with **Eight (8)** questions in **Fourteen (18)** pages.
2. Answer **Five (5)** questions including **Question 01** and selecting only **One (1)** question from **Section B.**
3. **Question 01** carry **40** marks. All the other questions carry **15 marks each.**
4. **Attach Page [7] of [18] to your answer script, if answered.**
5. Answer for each question should commence from a new page.
6. Relevant figures and tables are attached to this question paper
7. This is a Closed Book Test (CBT).
9. Answers should be in clear handwriting.
10. Do not use Red colour pen.

Section A – Electrical Installations

Question 01

A small factory to be built in Sri Lanka requires an electrical installation. It consists of continuously operating 15 kW load for heating and lighting in which one of the heating appliances consumes 4.6 kW. There are 3 machines in the factory which run by induction motors as details given in Table Q1.1. (Assume 1 horsepower (hp) = 746 W). Supply to the factory would be 400 V, 3-phase. Table Q1.2 shows the current demand at start for each starting method of motors. The voltage drop limitations can be neglected in the calculations and the harmonic currents in motors can be negligible.

Table Q1.1

Motor	Capacity (hp)	Supply	Starting method	Starting power factor	Running power factor
A	15	3-phase	Star-Delta	0.7	0.8
B	5	1-phase	DOL	0.7	0.8
C	5	1-phase	VFD	0.7	0.8

Table Q1.2

Type of starter	Starting current
DOL	6 times the full load current
Star-Delta	4 times the full load current
Soft Starter	2 times the full load current
VFD	1.5 times the full load current

Details of the wiring are as follows.

- Standby generator should be able to supply the maximum load in the factory.
- Ambient air and ground temperature is 25°C in the factory premises.
- Motor circuits are installed in thermally insulated walls in conduits using multicore PVC copper cables.
- Heating and lighting loads are distributed in the three phases and the circuits are installed in thermally insulated walls in conduits using single core copper cables.
- Both mains and standby generator supplies are PVC insulated multi core armoured copper cables laid underground, buried in cable ducts at 1 m depth with compact soil having 3 mK/W thermal resistivity.

Answer the following questions.

i. If the factory needs to install a standby generator, estimate the kVA rating of the generator. The switching order of motors is A – C – B. ***(15 marks)***

ii. Determine the appropriate protective devices and cable sizes for
   a. Motor circuits A, B and C
   b. Heating/Lighting system
   c. Mains and standby generator supply ***(10 marks)***

iii. Draw the complete wiring diagram indicating the mains, standby generator associated with switchgears and protective devices for all circuits. ***(15 marks)***

Question 02

Figure Q2 shows different sizes of metal conduits joined to a metal trunking in an industrial electrical installation. Assume that all loads are three phase loads.

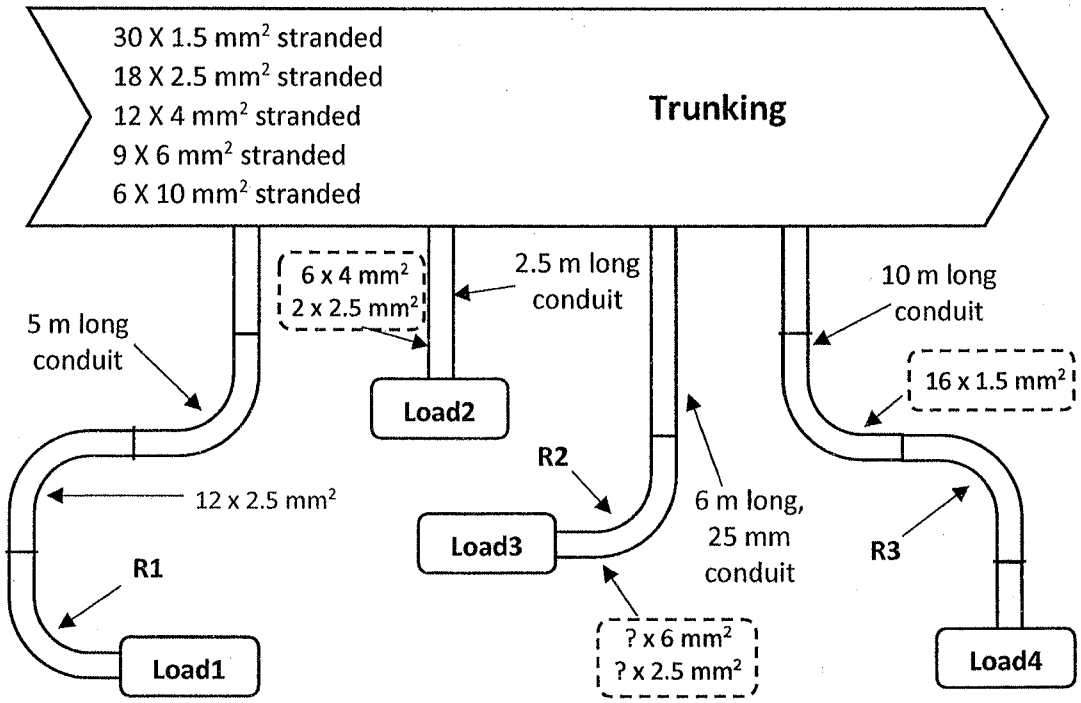


Figure Q2

Determine the following

i. Appropriate size for the main trunking system. ***(3 marks)***

ii. Suitable size of the conduit for Load 1. ***(2 marks)***

iii. Bending radius R1. ***(1 mark)***

iv. Suitable size of the conduit for Load 2. ***(2 marks)***

v. Number of 6 mm² and 2.5 mm² (CPC) cables in conduit connecting 3-phase Load 3. ***(3 marks)***

vi. Bending radius R2. ***(1 mark)***

vii. Suitable size of the conduit for Load 4. ***(2 marks)***

viii. Bending radius R3. ***(1 mark)***

Question 03

Conceptual single-line diagram of a certain electrical installation is shown in Figure Q3.

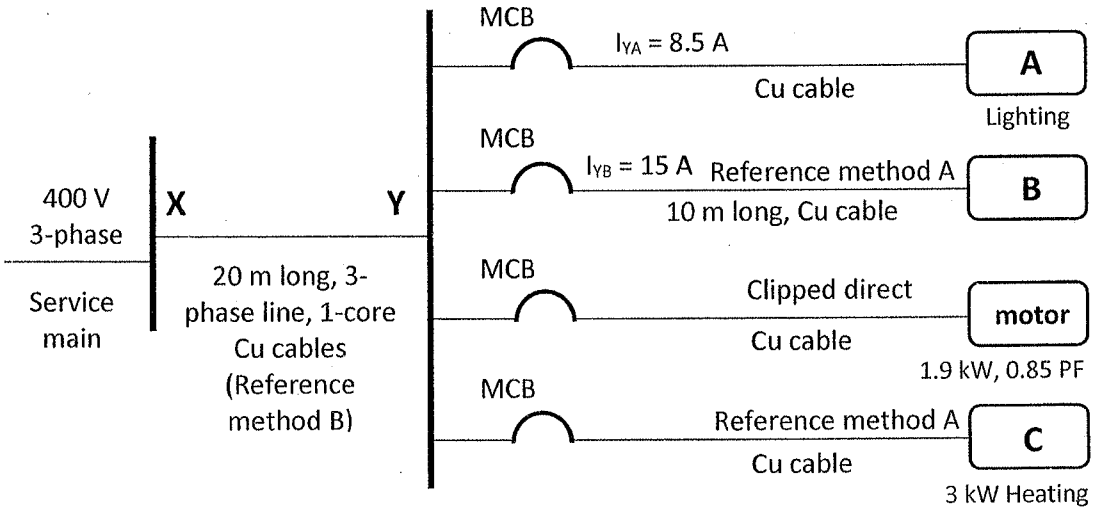


Figure Q3

A 3-phase service main of "a" mm^2 and a length of 20 m supplies a symmetrical 3 sets of identical A, B, C and a 1-phase motor loads connected to 3-phases emanating from bus-bar Y (only a single set of loads connected to one phase is shown in figure Q3 for clarity and simplicity). Permissible voltage drop allowed from X to each destination of load is 2.5%. Calculate the following.

i. Line current (I_{XY}) flowing in the 3-phase line XY. ***(2 marks)***
ii. Appropriate cable size "a" for 3-phase line. ***(2 marks)***
iii. Voltage at busbar Y. ***(2 marks)***
iv. Size of the MCB, cable size YA and its maximum length. ***(2 marks)***
v. Size of the MCB, cable size YB and the voltage at B. ***(2 marks)***
vi. Size of the MCB, cable size supplying the motor load and its maximum length. (You may assume that the starting current of the motor is twice that of the running current and the voltage drop of 5% is allowed at the start) ***(3 marks)***
vii. Size of the MCB, current flowing through cable YC, its size and maximum length. ***(2 marks)***

Question 04

i. Prove that the resistance R of (l m long and area A m^2) a rod earth-electrode driven into earth of soil resistivity ρ Ωm is given by, ***(4 marks)***

$$R = \frac{\rho}{4\pi l} \ln\left(\frac{l^2\pi}{A}\right)$$

ii. What would be the theoretical earth resistance of a 2.5 m long galvanized-iron (GI) pipe of diameter 60 mm firmly driven into a location with a soil resistivity of 100 Ωm. ***(4 marks)***
iii. State three methods that can be adopted to improve earth electrode resistance. ***(3 marks)***
iv. How many earth electrodes of (ii) above you need and how would you connect those electrodes to reduce the earth resistance of the premise to 5 Ω. ***(4 marks)***

Question 05

This question comprises either a direct question or a statement followed by several suggested answers. Only one of these answers is correct. Select the correct answer and write down the corresponding letter in the answer script. Wrong answer causes reduction of 1 mark and the minimum mark for this question is zero.

i. A person is receiving an electric shock while still in contact with the live equipment. The following action can be taken.

1. Send for medical assistance
2. Switch off the supply of electricity
3. Treat burns
4. Apply artificial respiration
5. Keep victim warm

Which order is the correct safety procedure? ***(1 mark)***

a) 1-5-3-2-4 b) 2-4-1-5-3 c) 2-3-1-5-4 d) 1-4-2-3-5

ii. When a fluorescent lamp continuously flickers it generally means that the: ***(1 mark)***

a) Starter switch in the control circuit is faulty.
b) Ballast is provided with low voltage.
c) Control circuit is not fitted with a power factor correction capacitor.
d) Lamp has reached the end of its life.

iii. The voltage of the continuity test must not exceed: ***(1 mark)***

a) 50 V b) 40 V c) 45 V d) 25 V

iv. An influencing factor when selecting a cable for a particular circuit is, ***(1 mark)***

a) Circuit protection b) Length of the run
c) Type of sheath d) Type of main earthing

v. Figure Q5.1 shows the circuit of a continuously ringing bell. ***(2 marks)***

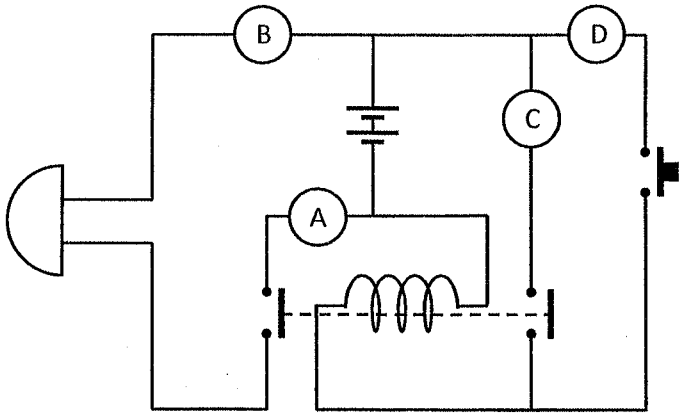


Figure Q5.1

To control the circuit, a reset button should be inserted at a position:

a) A b) B c) C d) D

vi. When bending a PVC conduit, permanent kinking may be prevented by: ***(1 mark)***

a) Initially heating the conduit
b) Heating the conduit during the process
c) Using a coiled steel spring inside the conduit
d) Using a hydraulic bending machine

vii. When using a Class II drill outdoors, it is essential that it is supplied from: ***(1 mark)***

a) A double-wound transformer b) A reduced voltage source
c) An RCD protected socket outlet d) An MCB distribution board

viii. Which of the following circuit protective devices has a relatively high fusing factor?

a) BS 3036 b) BS 1362 c) BS 1361 d) BS 88

(1 mark)

ix. In some discharging lighting installations, rotating machinery may appear to be stationary because of: ***(1 mark)***

a) Unbalanced loading of circuits b) Poor circuit power factor
c) Mixing types of lamp d) Stroboscopic effect

x. Figure Q5.2 shows a 30 A ring final circuit wired in PVC conduit.

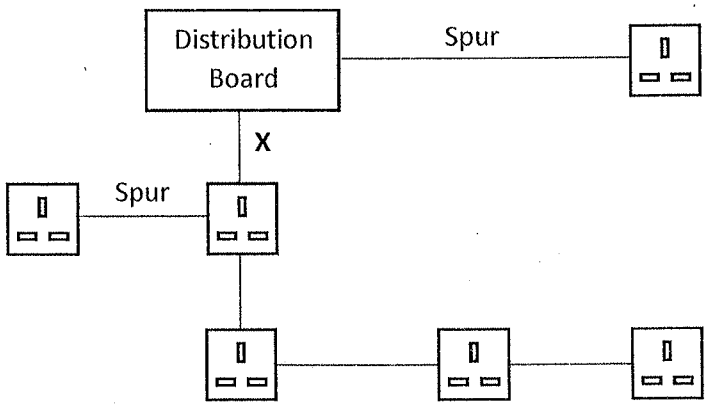


Figure Q5.2

The number of single-core PVC-insulated cables found in section X is: ***(3 marks)***

a) 9 b) 4 c) 6 d) 3

xi.

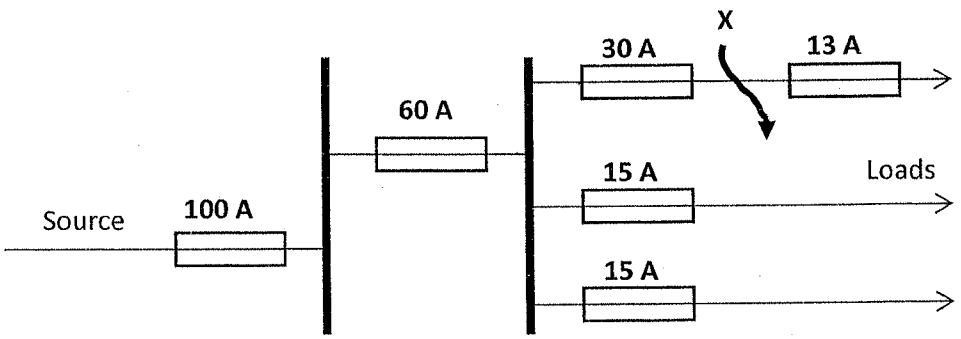


Figure Q5.3

Discrimination of operation of the fuses shown in Figure Q5.3 is said to have occurred if, when there is a short circuit at point X, the ***(1 mark)***

a) 13 A fuse ruptures b) 30 A fuse ruptures
c) 60 A fuse ruptures d) 100 A fuse ruptures

xii. Sri Lankan Government Decides on a Single Standard for Plugs and Socket Outlets from 1st January 2019. Architects, Engineers, Technicians and Electricians are advised to use only 13 ampere Standard Sockets in all new buildings with immediate effect. What type is it? ***(1 mark)***

a) Type-D b) Type-G c) Type-C d) Type-A

Question 06

A domestic electrical installation consisting of the following accessories are as shown in figure Q6 on page 7.

- MCB1 – 100 W lamp1, 100 W lamp2, 100 W lamp3, florescent lamp
- MCB2 – Ring circuit – points 1 to 6
- MCB3 – Point 7 – supplying a refrigerator of 250 W
- RCCB, Main switch, service main

i. Determine the ratings of MCB1, MCB2, MCB3 and the cable sizes for each circuit including protective conductor for each circuit. ***(4 marks)***

ii. State the type of device you recommend to the main switch. ***(3 marks)***

iii. State whether a single device can replace both RCCB and main switch. Justify your answer. ***(4 marks)***

iv. Draw the complete wiring diagram of the installation using the diagram provided in the question paper (page 7). You must detach the sheet from the question paper and attach it to your answer script. Use different colours (except red) and/or line styles (dashed/dotted) to indicate different wires in the diagram. ***(4 marks)***

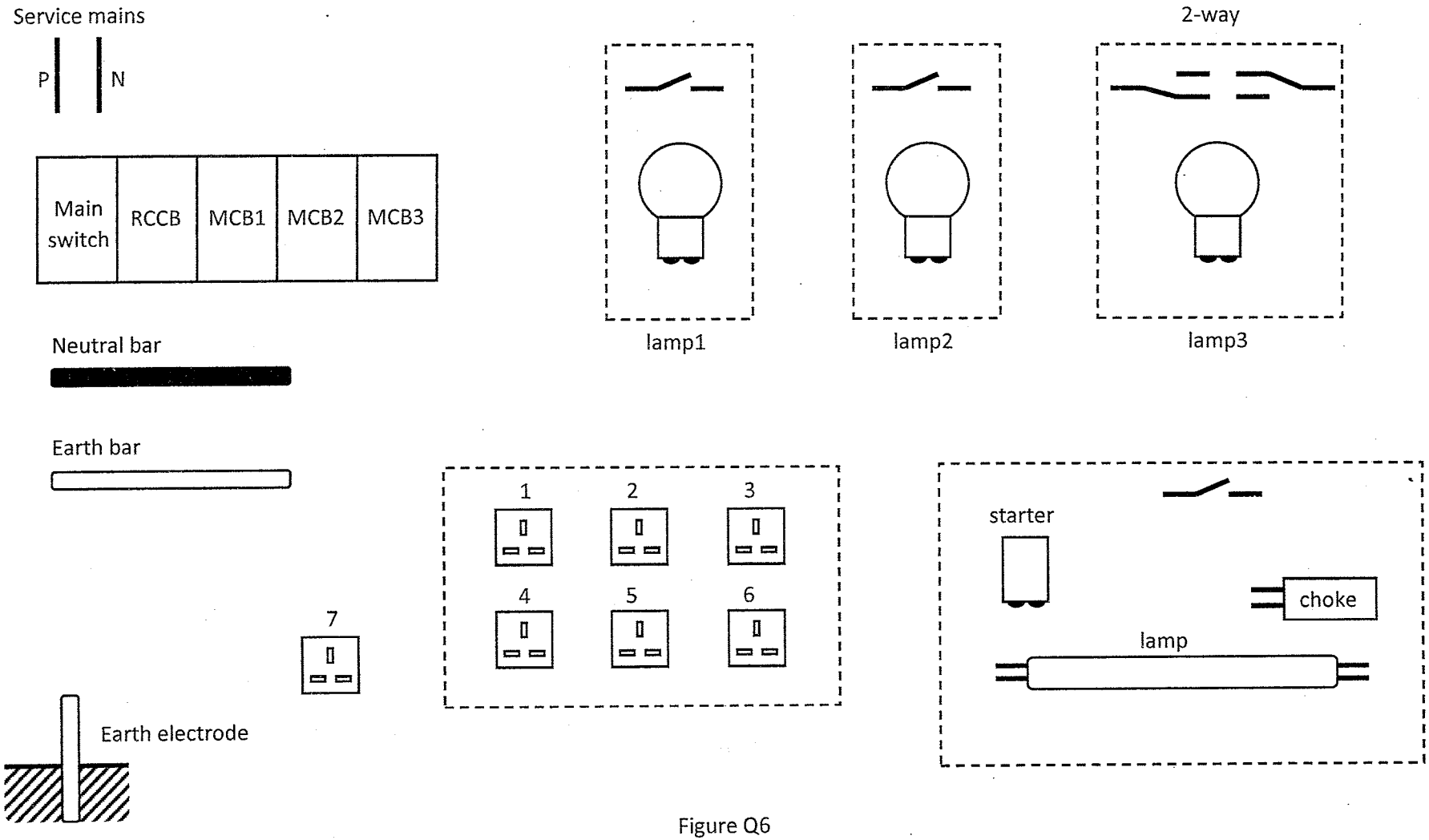

Service mains
P
N
Main switch
RCCB
MCB1
MCB2
MCB3
Neutral bar
Earth bar
7
Earth electrode
lamp1
lamp2
2-way
lamp3
1
2
3
4
5
6
starter
choke
lamp

Figure Q6

Section B – Lighting and Illumination

Question 07

Figure Q7 shows the layout plan of a university laboratory building. All the dimensions are given in meters. Ceiling height of the entire section is 3 m and work plane is 0.8 m from the floor. Design illuminance level at each area is as indicated in the layout plan. Assume 0.7, 0.5 and 0.3 reflection factors for ceiling, wall and floor respectively. Maintenance factor is 0.8 for all the cases. Answer the following questions. Clearly state any assumptions you made. The relevant data sheets of 3xTL5 14W and 13W downlight are given in pages 17 and 18.

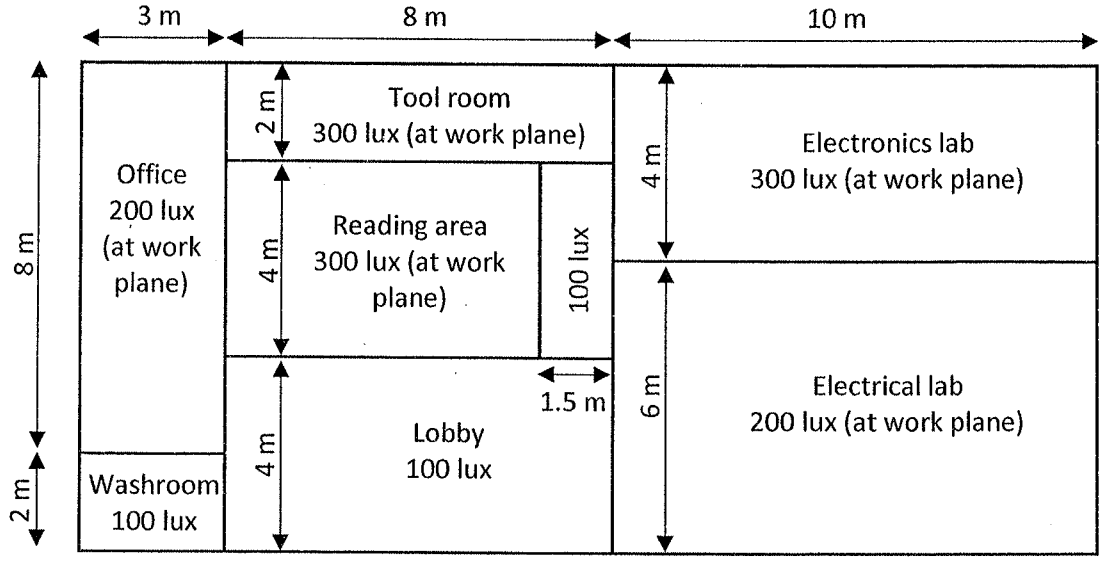


Figure Q7

i. What is the room index of the Electrical lab? ***(1 mark)***

ii. If 3xTL5 14W Fluorescent luminaire is selected for above section, what is the utilization factor? ***(1 mark)***

iii. Find the total lumens requirement for the Electrical lab. ***(1 mark)***

iv. Calculate the total number of 3xTL5 14W lighting fixtures required. ***(1 mark)***

v. Based on the answer of 'iv', propose suitable lighting fixture layout. Calculate the space to height ratio, lengthwise and widthwise for the selected layout. ***(3 marks)***

vi. Compare the answer of 'v' with the values given in the data sheet and state whether the proposed layout complies with the space to height ratio. ***(3 marks)***

vii. Calculate the number of lighting fixtures required for the tool room using 3xTL5 14W lighting fixtures. ***(2 marks)***

viii. Calculate the number of lighting fixtures required for the tool room using 13W downlight lighting fixtures. ***(2 marks)***

ix. If the price of a 3xTL5 14 W is Rs. 8000 and 13 W downlight is Rs. 3000, what is your choice of luminaire for the tool room? ***(1 marks)***

Question 08

Following are multiple choice questions. Select the correct answer and write down the corresponding letter in the answer script. Wrong answer causes reduction of 1 mark and the minimum mark for this question is zero. ***(15 x 1 mark = 15 marks)***

i. Which of the following sources would be most appropriate for the warehouse portion of a large furniture dealership?

a) high-pressure sodium b) metal-halide
c) cool-white deluxe fluorescent d) high- pressure mercury-vapor

ii. What is the most important criterion for lighting a fabric showroom?

a) visual comfort probability b) coefficient of utilization
c) color rendering index d) apparent color temperature rating

iii. Radiant efficiency of the luminous source depends on

a) shape of the source b) wavelength of light rays
c) temperature of the source d) all the above

iv. The unit of solid angle is in

a) solid angle b) radian c) steradian d) candela

v. Candela is the unit of

a) Luminous flux b) Luminous intensity
c) Wavelength d) None of the above

vi. Illumination level required for precision work is around

a) 50 lm/m2 b) 100 lm/m2 c) 200 lm/m^2 d) 500 lm/m^2

vii. Which lamp has the best Colour Rendering Index (CRI)?

a) Standard LED b) Fluorescent
c) Incandescent d) High pressure sodium vapour

viii. What will be the total flux emitted by a source of 90 candle power?

a) 1131 lumens b) 90 lumens
c) 1.13 lumens d) None of the above

ix. Illumination can be expressed in

a) radians b) lumens c) lux d) candela

x. A 200-candle power lamp is hung 4 m above the centre of circular area of 5 m diameter. The illumination at the centre of the area is

a) 13.5 lux b) 17.5 lux c) 12.5 lux d) 18.5 lux

xi. Light consists of:

a) electromagnetic waves b) ultraviolet waves
c) infrared waves d) gamma rays

xii. Illumination of a surface due to a source of light as per the first law of illumination is:

a) Inversely proportional to the distance between the surface and the source of light
b) Inversely proportional to the $(\text{distance})^2$ between the surface and the source of light
c) Directly proportional to the distance between the surface and the source of light
d) Directly proportional to the $(\text{distance})^2$ between the surface and the source of light

xiii. Colour of light depend upon

a) Frequency b) Wavelength c) both a) and b) d) speed of light

xiv. Illumination of one lumen per square meter is called

a) Lumen meter b) lux c) Foot candela d) candela

xv. Lumen/watt is the unit of

a) Light flux b) Brightness c) Luminous Intensity d) Luminous efficacy

Tables and charts

Rating factors (C_a) for ambient air temperatures other than 30°C (Extracted from Table 4B1)		
Ambient Temp. °C	Insulation 70 °C Thermoplastic	Insulation 90 °C Thermosetting
25	1.03	1.02
30	1.00	1.00
35	0.94	0.96
40	0.87	0.91

Rating factors (C_a) for ambient ground temperatures other than 20°C (Extracted from Table 4B2)		
Ground Temp. °C	Insulation 70 °C Thermoplastic	Insulation 90 °C Thermosetting
15	1.05	1.04
20	1.00	1.00
25	0.95	0.96
30	0.89	0.93

Rating factor (C_g) table for one circuit or for a group of circuits													
Arrangement of cables (touching)	Number of circuits or multicore cables												Laying Methods
	1	2	3	4	5	6	7	8	9	12	16	20	Reference
Bunched in air, on a surface, embedded or enclosed	1.00	0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.45	0.41	0.38	A to F
Single layer on wall or floor	1.00	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	0.70	0.70	0.70	C
Single layer multicore on a perforated horizontal or vertical cable tray system	1.00	0.88	0.82	0.77	0.75	0.73	0.72	0.72	0.72	0.72	0.72	0.72	E
Single layer multicore on cable ladder system or cleats	1.00	0.87	0.82	0.80	0.80	0.79	0.79	0.78	0.78	0.78	0.78	0.78	

Type B circuit-breaker to BS EN 60898 and RCBOs to BS EN 61009-1 characteristics

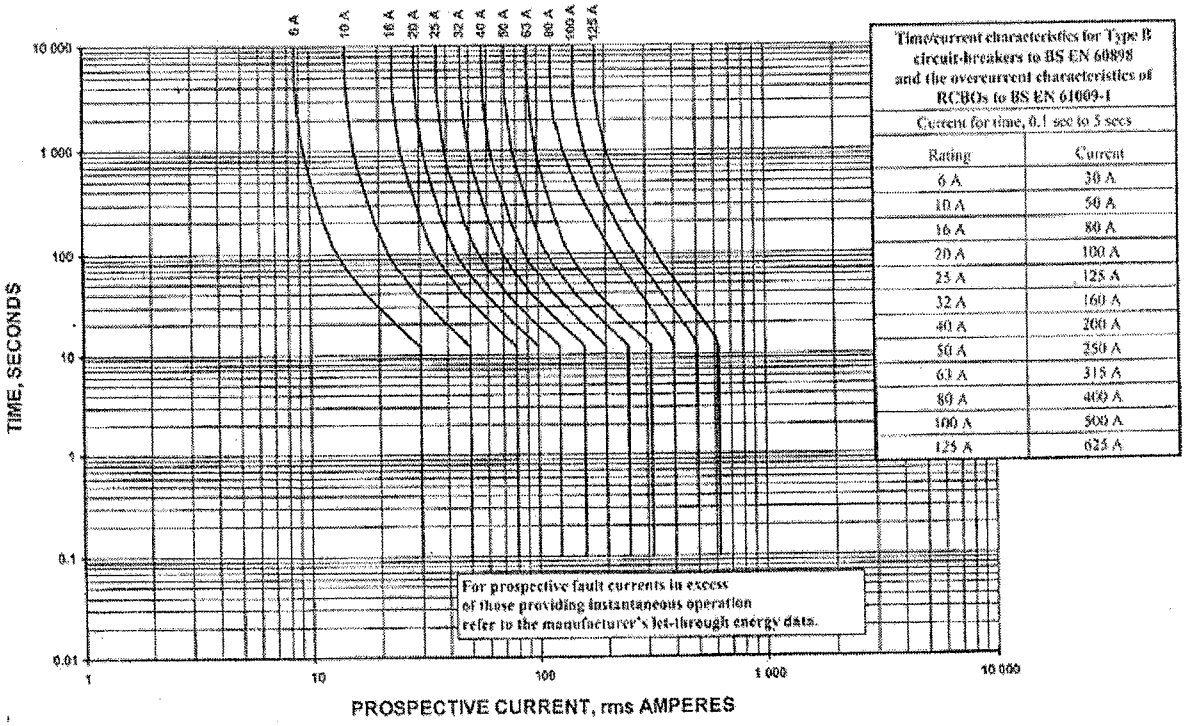


Table 4D2A – Multicore 70°C thermoplastic insulated and thermo plastic sheathed cables, non-armoured.

(COPPER CONDUCTORS)

CURRENT-CARYING CAPACITY (amperes): Conductor operating temperature: 70 °C, Ambient temperature: 30 °C

Conductor Cross Sectional area	Reference Method A (Enclosed in conduit in thermally insulating wall etc.)		Reference Method B (Enclosed in conduit on a wall or in trunking etc.)		Reference Method C (Clipped direct)		Reference Method E (in free air or on a perforated cable tray etc. horizontal or vertical)	
	1 two-core cable*. 1Φ AC or DC	1 three-core cable* or 1 Four-core cable, 3Φ AC	1 two-core cable*. 1Φ AC or DC	1 three-core cable* or 1 Four-core cable, 3Φ AC.	1 two-core cable*. 1Φ AC or DC	1 three-core cable* or 1 Four-core Cable, 3Φ AC	1 two-core cable*. 1Φ AC or DC	1 three-core cable* or 1 Four-core Cable, 3Φ AC
mm^2	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.
1	11	10	13	11.5	15	13.5	17	14.5
1.5	14	13	16.5	15	19.5	17.5	22	18.5
2.5	18.5	17.5	23	20	27	24	30	25
4	25	23	30	27	36	32	40	34
6	32	29	38	34	46	41	51	43
10	43	39	52	46	63	57	70	60
16	57	52	69	62	85	76	94	80
25	75	68	90	80	112	96	119	101
35	92	83	111	99	138	119	148	126
50	110	99	133	118	168	144	180	153
70	139	125	168	149	213	184	232	196
95	167	150	201	179	258	223	282	238
120	192	172	232	206	299	259	328	276
150	219	196	258	225	344	299	379	319
185	248	223	294	255	392	341	434	364
240	291	261	344	297	461	403	514	430
300	334	298	394	339	530	464	593	497
400	-	-	470	402	634	557	715	597

* With or without a protective conductor

1Φ – Single phase; 3Φ – Three phases

Table 4D2B – Multicore 70°C thermoplastic insulated cables, non-armoured, with or without sheath

(COPPER CONDUCTORS)

VOLTAGE DROP (per ampere per meter): Conductor operating temperature: 70 °C

Conductor Cross Sectional area	Two-core Cable. DC.	Two-core cable. Single-phase AC.			Three or Four-core cable. Three-phase AC.		
mm^2	mV/Amp/meter	mV/Amp/meter			mV/Amp/meter		
1	44	44			38		
1.5	29	29			25		
2.5	18	18			15		
4	11	11			9.5		
6	7.3	7.3			6.4		
10	4.4	4.4			3.8		
16	2.8	2.8			2.4		
		r	x	z	r	x	z
25	1.75	1.75	0.170	1.75	1.50	0.145	1.50
35	1.25	1.25	0.165	1.25	1.10	0.145	1.10
50	0.93	0.93	0.165	0.94	0.80	0.140	0.81
70	0.63	0.63	0.160	0.65	0.55	0.140	0.57
95	0.46	0.47	0.155	0.50	0.41	0.135	0.43
120	0.36	0.38	0.155	0.41	0.33	0.135	0.35
150	0.29	0.30	0.155	0.34	0.26	0.130	0.29
185	0.23	0.25	0.150	0.29	0.21	0.130	0.25
240	0.180	0.190	0.155	0.24	0.165	0.130	0.21
300	0.145	0.155	0.145	0.21	0.135	0.130	0.185
400	0.105	0.115	0.145	0.185	0.100	0.125	0.160

Table 4B3 – Rating factors (C_s) for cables buried direct in the ground or in an underground conduit system to BS EN 50086-2-4 for soil thermal resistivities other than 2.5 mK/W to be applied to the current carrying capacities for Reference Method D

Thermal resistivity K.m/W	0.5	0.8	1	1.2	1.5	2	2.5	3
Rating factor for cables in buried ducts	1.28	1.2	1.18	1.13	1.1	1.05	1	0.96
Rating factor for direct buried cables	1.88	1.62	1.5	1.4	1.28	1.12	1	0.90

Table 4B4 – Rating factors (C_d) for depths of laying other than 0.7m for direct buried cables and cables in buried ducts.

Depth of laying (meters)	Direct buried	Buried in ducts
0.5	1.03	1.02
0.7	1.00	1.00
1	0.97	0.98
1.25	0.95	0.96
1.5	0.94	0.95
1.75	0.93	0.94
2	0.92	0.93
2.5	0.90	0.92
3	0.89	0.91

Table 4D4A – Multicore armoured 70^{0}C thermoplastic insulated cables

(COPPER CONDUCTORS)

Ambient temperature: 30 ^{0}C Ground temperature: 20 0C

CURRENT-CARYING CAPACITY (amperes): Conductor operating temperature: 70 0C

Conductor Cross-Sectional Area	Reference Method C (Clipped direct)		Reference Method E (In free air or on a perforated cable tray etc. horizontal or vertical)		Reference Method D (direct in ground or in ducting in ground, in or around buildings)	
	1 two-core cable single-phase AC or DC	1 three- or four-core cable, three-phase AC	1 two-core cable. single-phase AC or DC	1 three- or four-core cable, three-phase AC	1 two-core cable. single-phase AC or DC	1 three- or four-core cable, three-phase AC
mm^2	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.
1.5	21	18	22	19	22	18
2.5	28	25	31	26	29	34
4	38	33	41	35	37	30
6	49	42	53	45	46	38
10	67	58	72	62	60	50
16	89	77	97	83	78	64
25	118	102	128	110	99	82
35	145	125	157	135	119	98
50	175	151	190	163	140	116
70	222	192	241	207	173	143
95	269	231	291	251	204	169
120	310	267	336	290	231	192
150	356	306	386	33	261	217
185	405	348	439	378	292	243
240	476	409	516	445	336	280
300	547	469	592	510	379	316
400	621	540	683	590	-	-

Source: IEE wiring Regulations 18th edition

Table 4D1A – Single-core 70°C thermoplastic insulated cables, non-armoured, with or without sheath

(COPPER CONDUCTORS)

CURRENT-CARYING CAPACITY (amperes): Ambient temperature: 30 °C Conductor operating temperature: 70°C

Conductor Cross Sectional area	Reference Method A (Enclosed in conduit in thermally insulating wall)		Reference Method B (Enclosed in conduit on a wall or in trunking)		Reference Method C (clipped direct)		Reference Method F (in free air or on a perforated cable tray horizontal or vertical)				
							Touching			Spaced by one diameter	
	2 cables. 1Φ AC or DC	3 or 4 cables. 3Φ AC	2 cables. 1Φ AC or DC	3 or 4 cables. 3Φ AC	2 cables. 1Φ AC or DC flat & touching	3 or 4 cables. 3Φ, AC flat & touching or trefoil	2 cables. 1Φ AC or DC flat	3 cables. 3Φ AC flat	3 cables. 3Φ AC trefoil	2 cables, 1Φ AC or DC or 3 cables 3Φ AC flat	
										Horizontal	Vertical
mm²	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.	Amps.
1	11	10.5	13.5	12	15.5	14	-	-	-	-	-
1.5	14.5	13.5	17.5	15.5	20	18	-	-	-	-	-
2.5	20	18	24	21	27	25	-	-	-	-	-
4	26	24	32	28	37	33	-	-	-	-	-
6	34	31	41	36	47	43	-	-	-	-	-
10	46	42	57	50	65	59	-	-	-	-	-
16	61	56	76	68	87	79	-	-	-	-	-
25	80	73	101	89	114	104	131	114	110	146	130
35	99	89	125	110	141	129	162	143	137	181	162
50	119	108	151	134	182	167	196	174	167	219	197
70	151	136	192	171	234	214	251	225	216	281	254
95	182	164	232	207	284	261	304	275	264	341	311
120	210	188	269	239	330	303	352	321	308	396	362
150	240	216	300	262	381	349	406	372	356	456	419
185	273	245	341	296	436	400	463	427	409	521	480
240	321	286	400	346	515	472	546	507	485	615	569
300	367	328	458	394	594	545	629	587	561	709	659

Table 4D1B – Single-core 70°C thermoplastic insulated cables, non-armoured, with or without sheath

(COPPER CONDUCTORS)

VOLTAGE DROP (per ampere per meter): Conductor operating temperature: 70 °C

Conductor Cross Sectional area	2 cables 1Φ a.c.			3 or 4 cables, 3 Φ a.c.		
	Reference Methods A & B (Enclosed in conduit or trunking)	Reference Methods C & F (clipped direct, on tray or in free air)		Reference Methods A & B (Enclosed in conduit or trunking)	Reference Methods C & F (clipped direct, on tray or in free air)	
		Cables touching	Cables spaced		Cables touching, Trefoil	Cables touching, Flat	Cables spaced*, Flat
mm²	mV/Amp/meter	mV/Amp/meter	mV/Amp/meter	mV/Amp/meter	mV/Amp/meter	mV/Amp/meter	mV/Amp/meter
1	44	44	44	38	38	38	38
1.5	29	29	29	25	25	25	25
2.5	18	18	18	15	15	15	15
4	11	11	11	9.5	9.5	9.5	9.5
6	7.3	7.3	7.3	6.4	6.4	6.4	6.4
10	4.4	4.4	4.4	3.8	3.8	3.8	3.8
16	2.8	2.8	2.8	2.4	2.4	2.4	2.4

	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z	r	x	z
25	1.80	0.33	1.80	1.75	0.20	1.75	1.75	0.29	1.80	1.50	0.29	1.55	1.50	0.175	1.50	1.50	0.25	1.55	1.50	0.32	1.55
35	1.30	0.31	1.30	1.25	0.195	1.25	1.25	0.28	1.30	1.10	0.27	1.10	1.10	0.170	1.10	1.10	0.24	1.10	1.10	0.32	1.15
50	0.95	0.30	1.00	0.93	0.190	0.95	0.93	0.28	0.97	0.81	0.26	0.85	0.80	0.165	0.82	0.80	0.24	0.84	0.80	0.32	0.85
70	0.65	0.29	0.72	0.63	0.185	0.66	0.63	0.27	0.69	0.56	0.25	0.61	0.55	0.160	0.57	0.55	0.24	0.60	0.55	0.31	0.63
95	0.49	0.28	0.56	0.47	0.180	0.50	0.47	0.27	0.54	0.42	0.24	0.48	0.41	0.155	0.43	0.41	0.23	0.47	0.40	0.31	0.51
120	0.39	0.27	0.47	0.37	0.175	0.41	0.37	0.26	0.45	0.33	0.23	0.41	0.32	0.15	0.36	0.32	0.23	0.40	0.32	0.30	0.44
150	0.31	0.27	0.41	0.30	0.175	0.34	0.29	0.26	0.39	0.27	0.23	0.36	0.26	0.15	0.30	0.26	0.23	0.34	0.26	0.30	0.40
185	0.25	0.27	0.37	0.24	0.170	0.29	0.24	0.26	0.35	0.22	0.23	0.32	0.21	0.145	0.26	0.21	0.22	0.31	0.21	0.30	0.36
240	0.195	0.26	0.33	0.185	0.165	0.25	0.185	0.25	0.31	0.17	0.23	0.29	0.16	0.145	0.22	0.16	0.22	0.27	0.16	0.29	0.34
300	0.160	0.26	0.31	0.150	0.165	0.22	0.150	0.25	0.29	0.14	0.23	0.27	0.13	0.14	0.19	0.13	0.22	0.25	0.13	0.29	0.32

1Φ – Single phase; 3Φ – Three phases; Note: * - Spacing larger than one cable diameter will result in a larger voltage drop.

Source: IEE wiring Regulations 18th edition

FACTORS FOR TRUNKING

Cable factors for Trunking		
Type of conductor	Conductor cross-sectional area mm²	Factor
Solid	1	7.1
	2.5	10.2
Stranded	1.5	8.1
	2.5	11.4
	4	15.2
	6	22.9
	10	36.3

Factor for Trunking			
Dimension of trunking (mm x mm)	Factor	Dimension of trunking (mm x mm)	Factor
50 x 37.5	767	100 x 37.5	1542
50 x 50	1037	100 x 50	2091
75 x 25	738	100 x 75	3189
75 x 37.5	1146	100 x 100	4252
75 x 50	1555		
75 x 75	2371		
100 x 25	993		

FACTORS FOR CONDUITS

Cable Factors for straight runs ≤ 3 m		
Type of conductor	Conductor cross-sectional area mm²	Factor
Solid	1	22
	1.5	27
	2.5	39
Stranded	1.5	31
	2.5	43
	4	58
	6	88
	10	146

Conduit factors for straight runs ≤ 3 m	
Conduit diameter (mm)	Factor
16	290
20	460
25	800
32	1400

Cable factors for long straight runs > 3 m or runs incorporating bends

Type of conductor	Conductor cross-sectional area mm²	Factor
Solid or stranded	1	16
	1.5	22
	2.5	30
	4	43
	6	58
	10	105

Conduit factors for runs incorporating bends.

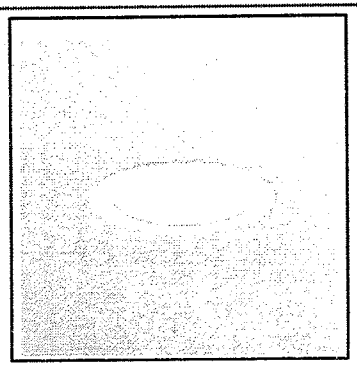
Length Of run (m)	Conduit diameter, mm																			
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
	Straight				One bend				Two bends				Three bends				Four bends			
1	290	460	800	1400	188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5	290	460	800	1400	182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
2	290	460	800	1400	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
2.5	290	460	800	1400	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
3	290	460	800	1400	167	270	487	857	143	233	422	750	111	182	333	600				
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563				
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529				
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500				
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474				
6	167	270	487	857	143	233	422	750	111	182	333	600								
7	162	263	475	837	136	222	404	720	103	169	311	563								
8	158	256	463	818	130	213	388	692	97	159	292	529								
9	154	250	452	800	125	204	373	667	91	149	275	500								
10	150	244	442	783	120	196	358	643	86	141	260	474								

Source: IEE wiring Regulations 15th and 17th edition

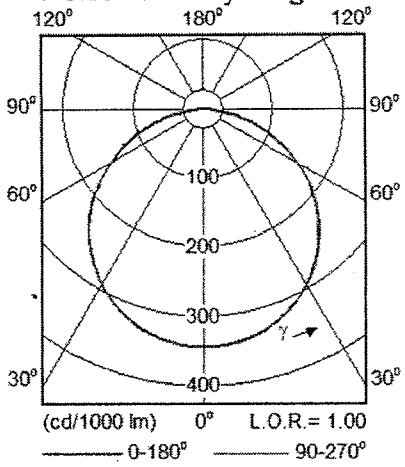
Total Lamp Flux	: 1000 lm
Light Output Ratio	: 1.00
Luminous Flux	: 1000 lm
Power	: 13 W
HxD	: 0.03x0.17 m
Ballast	: -

DN135B D165 1xLED10S/830

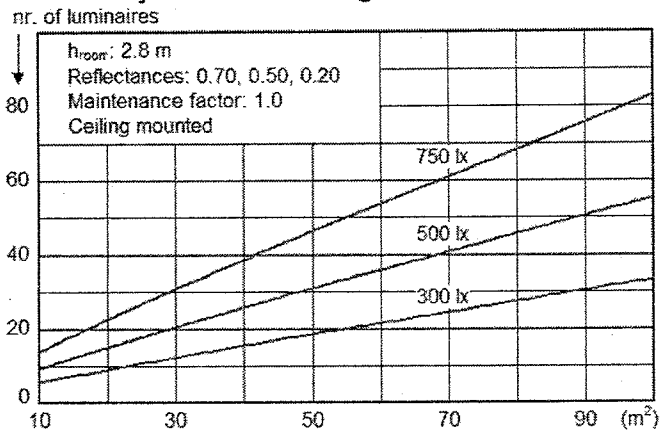
1 x 1000 lm



Polar intensity diagram



Quantity estimation diagram



Light output ratio	1.00
Service upward	0.00
Service downward	1.00
CIE flux code	46 78 95 100 100
S/H ratio crosswise	max. 1.6
lengthwise	max. 1.6
UTE71-121:	1.00AS + 0.00T

Utilisation factor table

Room Index k	Reflectances for ceiling, walls and working plane (CIE)										
	0.80	0.80	0.70	0.70	0.70	0.70	0.50	0.50	0.30	0.30	0.00
	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.10	0.30	0.10	0.00
	0.30	0.10	0.30	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.00
0.60	0.47	0.45	0.47	0.46	0.45	0.37	0.37	0.32	0.36	0.32	0.30
0.80	0.58	0.55	0.57	0.56	0.54	0.46	0.46	0.41	0.45	0.40	0.38
1.00	0.67	0.62	0.66	0.64	0.62	0.54	0.53	0.48	0.52	0.48	0.45
1.25	0.76	0.70	0.74	0.71	0.69	0.62	0.61	0.56	0.60	0.55	0.53
1.50	0.82	0.75	0.80	0.77	0.74	0.67	0.66	0.61	0.65	0.61	0.58
2.00	0.92	0.83	0.90	0.86	0.82	0.76	0.75	0.70	0.73	0.70	0.67
2.50	0.99	0.88	0.96	0.91	0.86	0.82	0.80	0.76	0.79	0.76	0.73
3.00	1.04	0.91	1.01	0.95	0.90	0.86	0.84	0.81	0.83	0.80	0.77
4.00	1.10	0.95	1.07	1.00	0.94	0.91	0.89	0.86	0.87	0.85	0.82
5.00	1.14	0.98	1.10	1.03	0.97	0.94	0.92	0.90	0.90	0.88	0.85

Ceiling mounted

Luminance Table

Plane / Cone	0.0	45.0	90.0
45.0	19820	19931	19974
50.0	19551	19673	19711
55.0	19196	19344	19408
60.0	18763	18908	18993
65.0	18186	18343	18444
70.0	17478	17637	17779
75.0	16521	16661	16872
80.0	15276	15486	15800
85.0	13273	13828	14315
90.0	-	-	-

(cd/m2)

LVE2568600

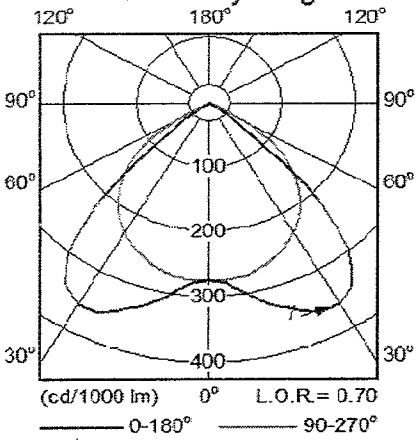
2020-06-05

Total Lamp Flux	: 3600 lm
Light Output Ratio	: 0.70
Luminous Flux	: 2520 lm
Power	: 46 W
LxBxH	: 0.60x0.60x0.05 m
Ballast	: HF Standard

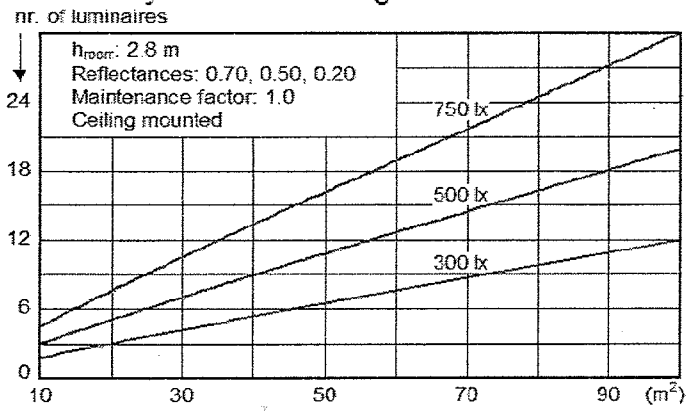
TBS165 G 3xTL5-14W HFS C6

3 x 1200 lm

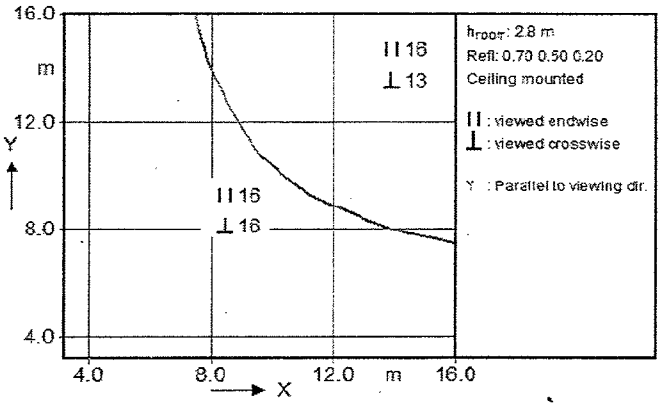
Polar intensity diagram



Quantity estimation diagram



UGR diagram



Light output ratio	0.70
Service upward	0.00
Service downward	0.70
CIE flux code	66 98 100 100 70
S/H ratio crosswise	max. 1.9 1.8
lengthwise	max. 1.2
UGRcen (4Hx8H, 0.25H)	15
EN12464-1	65 deg, 500 cd/m2
UTE71-121:	0.70C + 0.00T

Utilisation factor table

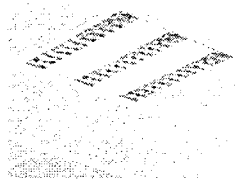
Room Index k	Reflectances for ceiling, walls and working plane (CIE)									
	0.80 0.50 0.30	0.80 0.50 0.10	0.70 0.50 0.30	0.70 0.50 0.20	0.70 0.50 0.10	0.70 0.30 0.10	0.50 0.30 0.10	0.50 0.30 0.10	0.30 0.10 0.10	0.00 0.00 0.00
0.60	0.41	0.39	0.41	0.40	0.39	0.34	0.34	0.31	0.34	0.31	0.30
0.80	0.48	0.46	0.49	0.47	0.45	0.42	0.41	0.38	0.41	0.38	0.37
1.00	0.56	0.52	0.55	0.53	0.51	0.48	0.47	0.44	0.47	0.44	0.43
1.25	0.62	0.57	0.61	0.58	0.56	0.53	0.52	0.50	0.51	0.49	0.48
1.50	0.66	0.60	0.65	0.62	0.59	0.56	0.56	0.53	0.55	0.53	0.51
2.00	0.72	0.64	0.71	0.67	0.64	0.61	0.61	0.59	0.60	0.58	0.57
2.50	0.76	0.67	0.74	0.70	0.66	0.64	0.63	0.62	0.62	0.61	0.60
3.00	0.79	0.69	0.76	0.72	0.69	0.66	0.65	0.64	0.64	0.63	0.62
4.00	0.81	0.70	0.79	0.74	0.70	0.68	0.67	0.66	0.66	0.65	0.63
5.00	0.83	0.71	0.81	0.75	0.71	0.69	0.68	0.67	0.67	0.66	0.65

Ceiling mounted

Luminance Table

Plane / Cone	0.0	45.0	90.0
45.0	3342	4062	2702
50.0	1257	3197	2459
55.0	455	1875	2119
60.0	81	560	1231
65.0	39	150	331
70.0	29	38	35
75.0	21	17	21
80.0	19	13	19
85.0	13	13	13
90.0	-	-	-

(cd/m2)



LVW1675400

2020-06-05