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

Study Program	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4434 Electrical Installations**
Academic Year	: 2020/21
Date	: 05th February 2022
Time	: 1400-1700 hrs.
Duration	: **3 hours**

General Instructions

1. Read all the instructions carefully before answering the question paper.
2. This question paper consists of two sections, **Section A** and **Section B** with **Eight (8)** questions in **Sixteen (16)** pages.
3. Answer totally **Five (5)** questions selecting only **One (1)** question from **Section B.**
4. **Question #1** carry **40** marks. All the other questions carry **15 equal marks.**
5. **Attach Page [6] of [16] to your answer script if Q#6 is answered.**
6. Answer for each question should commence from a new page.
7. Relevant figures and tables are attached to this question paper.
8. This is a Closed Book Test (CBT).
9. Answers should be in clear handwriting.
10. Do not use Red colour pen.

Section A-Electrical Installation

1. A small tea factory is to be built in the hill country of Sri Lanka with a heating and lighting load of 15 kW operating continuously. Rest of the load would be consisting of four induction motors detailed in the table given below. The motor with a capacity of 15 hp is operating at three-phase, 400V and the other three motors are operating at single-phase, 230V.

Motor	Capacity (hp)	Operating at	Staring method	Starting power factor	Running power factor
A	15	3-phase	Star-Delta	0.7	0.8
B	5	1-phase	Direct Online	0.7	0.8
C	5	1-phase	Soft Starter	0.7	0.8
D	5	1-phase	Variable Frequency drive	0.7	0.8

As there are frequent power failures observed in the 400V three phase distribution network in the district where the factory is to be built, it was decided to install a standby generator too by the factory management. Under the circumstances, motors will be switched on in the order of A-B-C-D. Since it would be a small factory, it is not necessary to consider the voltage drop limitations. The harmonic content of the motor currents is negligible.

a. Recommend the kVA rating of the standby generator required for this factory.
(Assume the following data when calculating the size of standby diesel generator for domestic/commercial and industrial use:) **[15 Marks]**

Type of Starter	Starting Current
Direct online	6 times the Full Load Current
Star-Delta	4 times the Full Load Current
Soft Starter	2 times the Full Load Current
Variable Frequency drive	1.5 times the Full Load Current

b. Design the appropriate protective devices and cable sizes for:

i. Motor circuits A, B, C and D **[5 Marks]**
ii. Heating/lighting system of the factory. **[5 Marks]**
iii. Mains and standby generator supply **[5 Marks]**

You may make the following assumptions during the calculations:

- *Both **ambient air** and **ground** temperature is 25^{0}C in the factory premises.*
- *Motor circuits are installed in thermally insulated walls in conduits using **multi core** pvc copper cables.*
- *Heating and lighting loads are balanced in the three phases and the circuits are installed in thermally insulated walls in conduits using **single core** copper cables.*
- *Standby supply should be capable of supplying the total electric load*
- *Both mains and standby generator supply are pvc insulated **multi core armoured** copper conductors laid **underground, buried in cable ducts** at **one meter depth** with compact soil having 3 K.m/W thermal resistivity.*

c. Draw the complete wiring diagram indicating the mains, standby generator supply with associated switchgears and protective devices for motors and heating/lighting circuits. **[10 Marks]**

* *Relevant tables and data are given in Page [10] of [16] to [13] of [16] for easy reference.*

2. A single phase 230 V, 3 kVA electric appliance **A** is to be fed from a distribution board as shown in figure Q2. The pvc insulated copper (thermo-plastic) cable circuit associated with 2.5 mm^2 copper cpc is recommended for this installation is enclosed in a conduit with 2 other similar size cable circuits, embedded in a wall. The maximum and minimum ambient temperatures at the installation are observed to be 30^0C and 32 ^{0}C respectively.

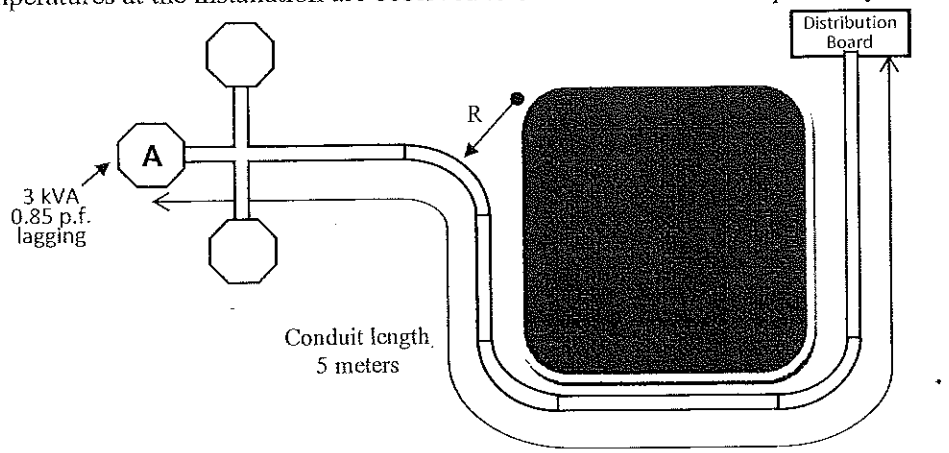


Figure Q2

a. Determine the design current for the appliance **[1 Marks]**

b. Select, rating of the device if it is to be protected by type-B circuit breaker to BS EN60898 **[1 Marks]**

c. Calculate the value C_a for computing the cable rating **[1 Marks]**

d. What is the suitable value of C_g for computing the cable rating **[1 Marks]**

e. Compute the required ampere rating of this cable **[1 Marks]**

f. What should be its cross-sectional area **[1 Marks]**

g. What voltage would you experience at the appliance **[1 Marks]**

h. What diameter would you recommend for the conduit **[1 Marks]**

i. Calculate the minimum value for bending radius **R** **[1 Marks]**

j. Had it been protected by a 6A type-B circuit breaker to BS EN 60898 by mistake, what would have been the tripping time of the breaker **[2 Marks]**

k. If the earth fault loop impedance external to the installation is 0.8 Ω and size of the cpc is 2.5 mm^2, check whether the circuit is satisfying the adiabatic equation.

(Assume that the parameter k to be 115) **[2 Marks]**

l. Calculate the maximum time the conductor could withstand as per the adiabatic equation if one wished to introduce an internal time delay for the circuit breaker. **[2 Marks]**

* *Relevant tables and data are given in Page [10] of [16] to [13] of [16] for easy reference.*

3. Figure Q3 shows three metal conduits joined to a section of metal trunking in an industrial electrical installation. Determine:

a. An appropriate size for the main trunking system **A** ⟶ **B** **[1 Marks]**

b. The size of the conduit for load **L1** **[2 Marks]**

c. Conduit bending radius $\mathbf{R_1}$ **[2 Marks]**

d. The size for trunking system **B** ⟶ **C** *(AB to BC should be compatible)* **[2 Marks]**

e. Number of 6 mm² cables in conduit for Load **L2** **[2 Marks]**

f. Conduit bending radius $\mathbf{R_2}$ **[2 Marks]**

g. The size for trunking system **C** ⟶ **D** *(BC to CD should be compatible)* **[2 Marks]**

h) The size of the conduit for Load **L3** **[2 Marks]**

** Relevant tables and data are given in Page [14] of [16] for easy reference.*

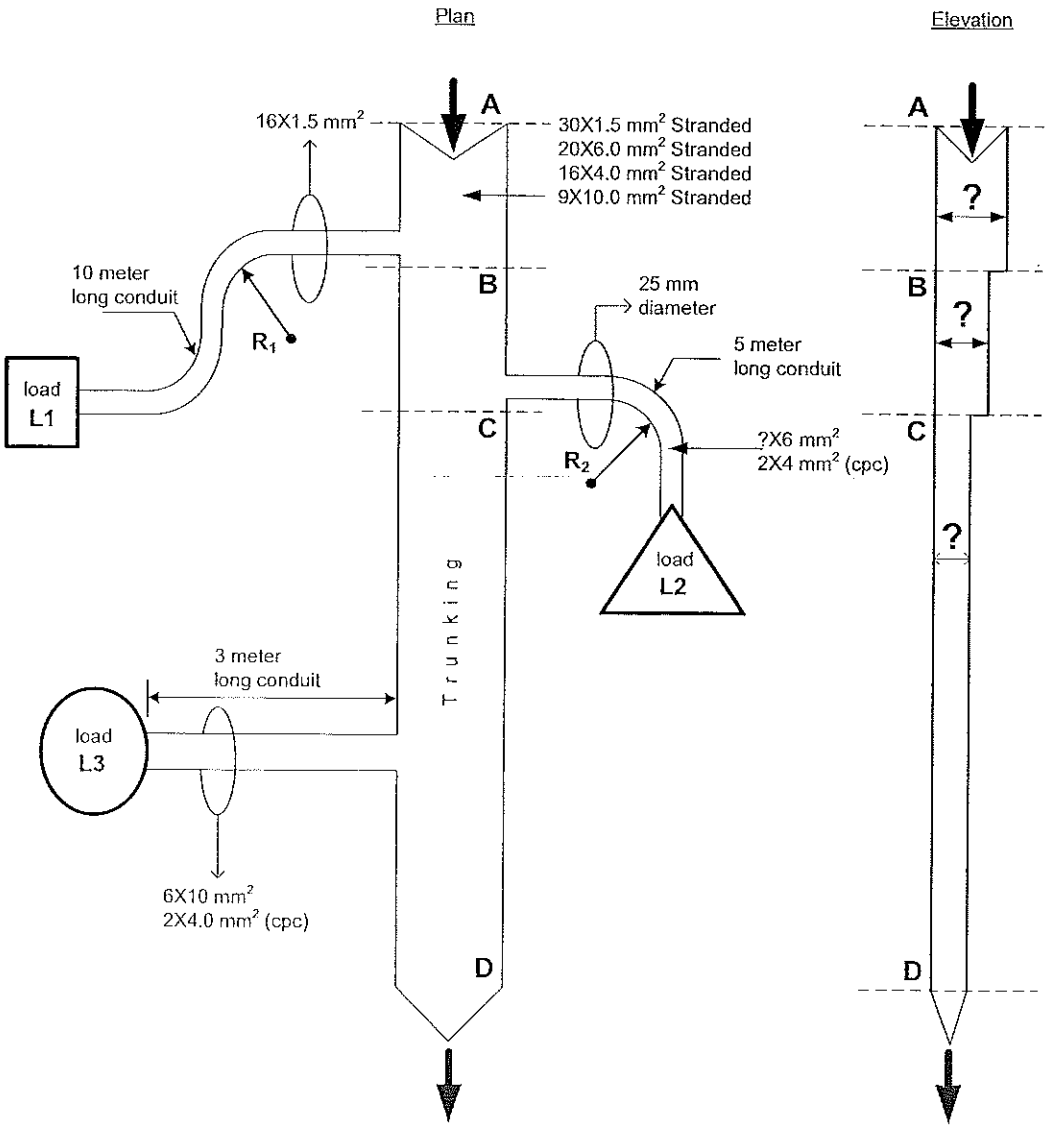


Figure Q3

4. a. To determine the earth fault loop impedance of a "spur" on a ring circuit, strictly it is necessary to estimate the fractional distance of that spur from the origin of the circuit. If the fraction is denoted by '*y*' as shown in figure Q4, prove that the earth fault loop impedance at the remote end of spur is given by:

$$Z_S = \lfloor Z_E + y(1-y)(R_{1T} + R_{2T}) + R_{1S} + R_{2S} \rfloor \text{ Ohm}$$ **[5 Marks]**

Where:

R_{1T} = Total resistance of the phase conductor of the ring circuit in Ohm.

R_{2T} = Total resistance of the protective conductor of the ring circuit in Ohm.

R_{1S} = Resistance of the phase conductor of the spur in Ohm.

R_{2S} = Resistance of the protective conductor of the spur in Ohm.

Z_E = Earth fault loop impedance external to the installation in Ohm.

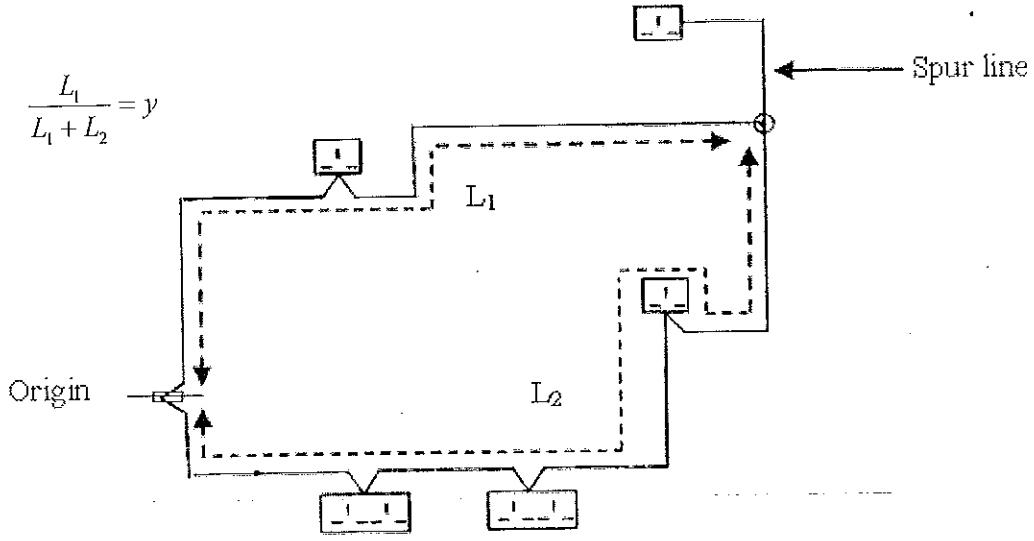


Figure Q4

b. Deduce that under the worst-case scenario, the above computed value would be:

$$Z_S = \lfloor Z_E + 0.25(R_{1T} + R_{2T}) + R_{1S} + R_{2S} \rfloor \text{ Ohm}$$ **[5 Marks]**

c. A single-phase ring circuit is run in 2.5 mm^2 70 ^{0}C pvc-insulated and sheathed flat cable with the protective conductor being 1.5 mm^2. Measured length of the ring circuit is about 100 m. A spur taken from the ring is run in the same cable and the length of the spur being 10 m. If the spur is taken from the ring is 40 m from the origin and Z_E = 0.45, what is the earth fault loop impedance for the spur line? **[3 Marks]**

d. Explain the variation of the calculated value in **4b,** if the point where the spur is taken from the ring circuit varies around the circuit? To get a pessimistically high result for you to be on the safe side, what would be the highest value of the earth fault loop impedance you would estimate for 10 m spur in above ring circuit? **[2 Marks]**

5. a. Determine the resistance of (l meter long with a cross sectional area A) a rod electrode driven into the earth using the basic equation $R = \frac{\rho l}{A}$. Symbols have their usual meanings. *[Hint-Elevation & plan of the equipotential lines built up during a fault current driven into the ground are as shown in figure Q5a &Q5b respectively.]* **[4 Marks]**

b. Compute the expected earth resistance of a 2m long GI pipe of diameter 50 mm firmly driven into a soil of resistivity 120 Ωm. **[3 Marks]**

c. State three methods that can be adopted to improve earth electrode resistance. **[3 Marks]**

d. How many earth electrodes of (b) above you need and how would you connect those electrodes to reduce the earth resistance of the place (120Ωm soil resistivity) to 5Ω? **[3 Marks]**

e. State two commonly used method of arrangements for determination of soil resistivity **[2 Marks]**

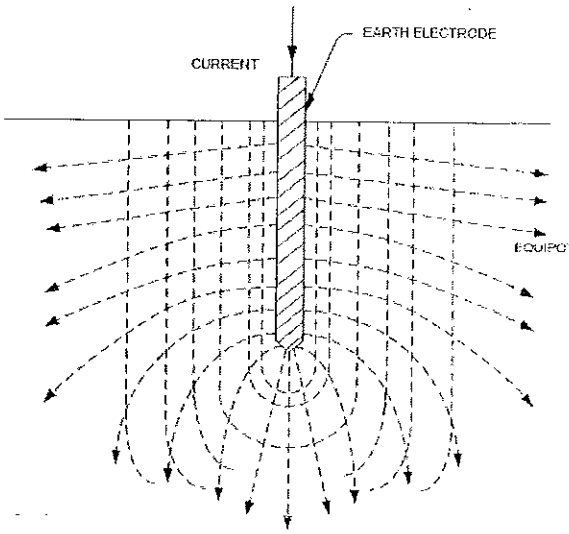


Figure Q5a-Elevation

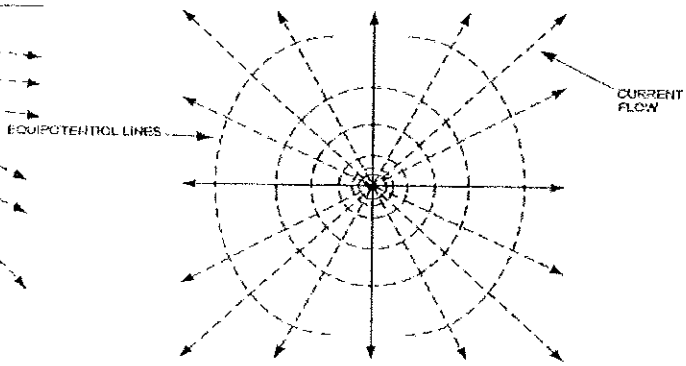


Figure Q5b-Plan

6. A domestic electrical installation consisting of the following accessories are as shown in page [6] of [16]:

a. MCB1 ⇒ Supplying 100W lamp#1, 100W lamp#2, 100W lamp#3, 13Amp plug point#4 and a 40W fluorescent lamp#5

b. MCB2 ⇒ Supplying plug points p & q radially (13Amp sockets)

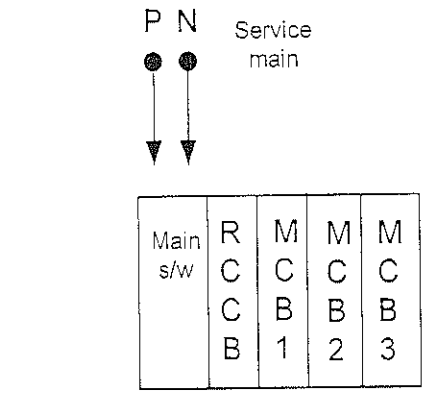
c. MCB3 ⇒ Supplying a ring circuit with plug points a, b, c, d, e and f (13Amp sockets)

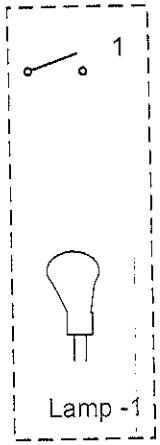
d. RCCB, Main switch and a service main

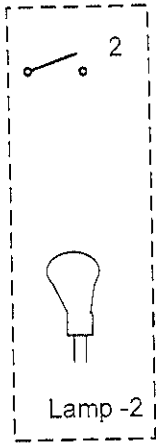
I Draw the complete wiring diagram starting from the service main on this page and attach it to your answer script. *(Use different colors for phase, neutral and earth wires or different line styles).* **[8 Marks]**

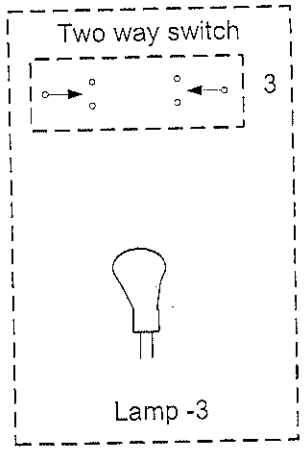
II Determine the ratings of MCB2 and MCB3 and the appropriate sizes of cables for both the radial and the ring circuits respectively. **[4 Marks]**

III State the main difference between MCB and RCCB **[3 Marks]**

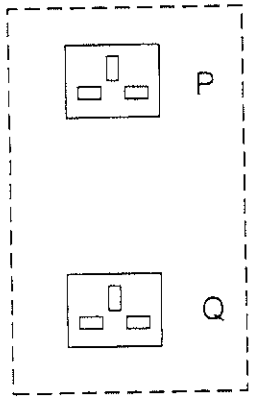

P N
Service main
Main s/w
RCCB
MCB1
MCB2
MCB3
Neutral Bar
Earth Bar

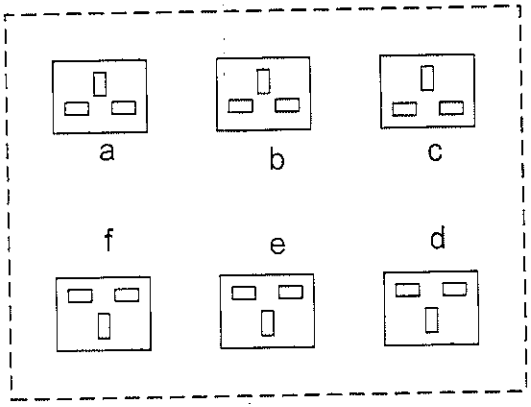

1
Lamp -1

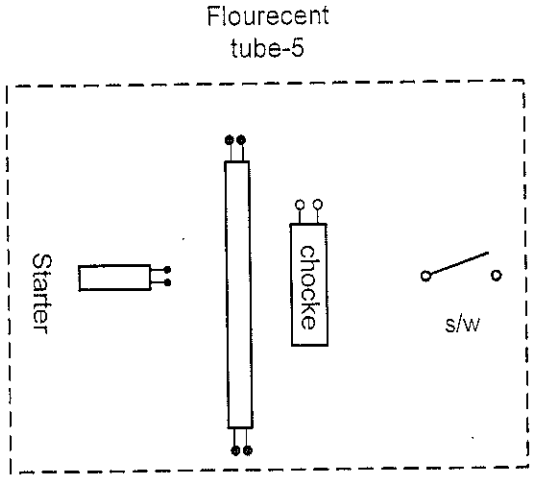

2
Lamp -2


Two way switch
3
Lamp -3


Plug point - 4


P
Q


ring circuit
a
b
c
f
e
d


Flourecent tube-5
Starter
chocke
s/w

Section B-Lighting and Illumination

7. Following are the multiple type questions. select the correct answer **[1*15 marks]**

1. Candela is the unit of
   a) Luminous flux b) Luminous intensity c) Wavelength d) Brightness

2. The illumination of the surface varies directly with cosine of the angle between normal to surface and direction of the inclined light is given by,
   a. law of square inverse
   b. Lambert's cosine law
   c. both a and b
   d. none of the above

3. Which of the following will need the highest level of illumination?
   a. Cinema Halls
   b. Bedrooms
   c. Washrooms
   d. Proof Reading

4. The unit of solid angle is in
   a) solid angle b) radian c) steradian d) candela

5. Illumination of one lumen per square meter is called
   a) Lumen meter b) Lux c) Foot candela d) candela

6. Which of the following lamp has the best Colour Rendering Index (CRI)?
   a) LED b) Fluorescent c) Halogen Lamp d) High pressure sodium vapour

7. What will be the total flux emitted by a source of 60 candle power?
   a) 754 lumens b) 377 lumens c) 75.4 lumens d) 37.7

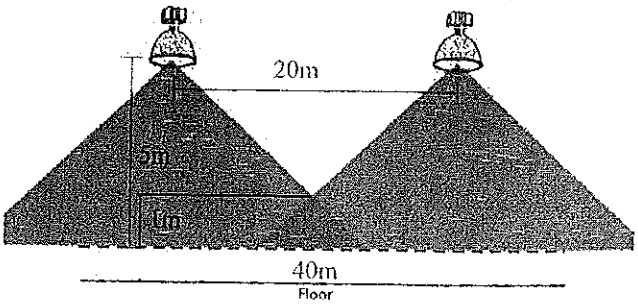
8. The ratio of total luminous flux reaching the working plane to the total luminous flux given out by the lamp is called,
   a) Reflection Factor b) Maintenance Factor c) Efficacy d) Utilization Factor

9. A 400-candle power lamp is placed 8 m above the centre of circular area of 5 m diameter. The illumination at centre of the area is
   a) 16 lux b) 12.5 lux c) 6.25 lux d) 8.5 lux

10. The amount of visible light which comes to the eyes from surface is known as,
    a) Light flux b) Brightness c) Illuminance d) Luminous

11. Which of the following has the lowest colour temperature?
    a) Incandescent bulb b) Candles c) Halogen Bulb d) Moon Light

12. The space to height ratio of the following luminaires from floor is given by,
    a) 10 b) 5 c) 4 d) 8



13. 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 (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 (distance)^2 between the surface and the source of light

14. Luminous efficacy of a fluorescent tube is

a. 5- 10 lumens/watt
b. 15-20 lumens/watt
c. 30 - 40 lumens/watt
d. 60 - 65 lumens/watt

15. Which of the following is not a type of lighting scheme?

a. Semi Direct
b. General Diffused
c. Semi Diffused
d. Semi Indirect

8. Following figure shows you the layout plan of a collage building. All the dimensions are given in meters. Ceiling height of the entire section is 3m and work plane is 0.8m from the floor. Design illuminance levels at each area is as given in the figure Q8. A 3x14W, T5 Fluorescent, ceiling recessed mounted light fitting and a 13W downlight are selected for the lighting of the entire section and the data sheets for above luminaires are given in the Page [15] of [16] and [16] of [16]. 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.

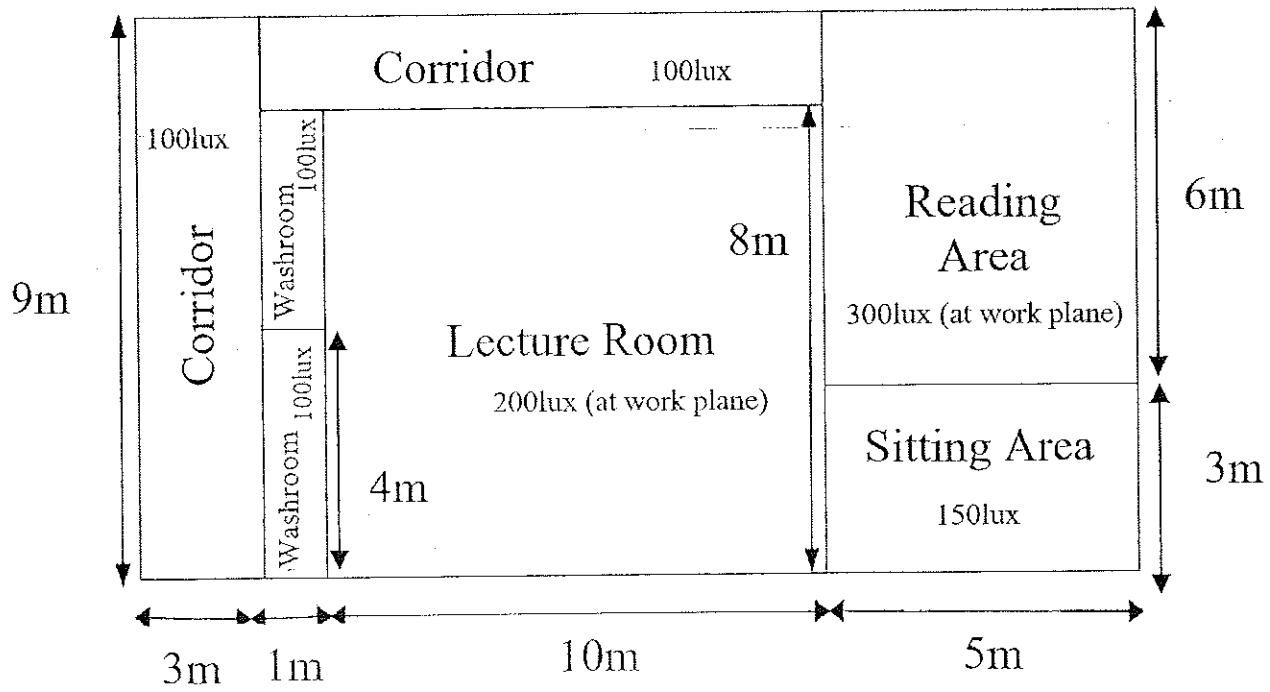


Figure Q8

i. What is the room index of the Lecture Room? **[1Mark]**

ii. What will be the utilization factor if the lecture room is going to illuminate by 3x14W, T5 Fluorescent lamps? **[1Mark]**

iii. Calculate the total Lumens requirement for the lecture room? **[1Mark]**

iv. Calculate the total number of 3x14W, T5 Fluorescent lamp lighting fixtures required for the lecture room? **[1Mark]**

v. Propose suitable lighting fixture layouts based on the value calculated in section (iv)? **[2Marks]**

vi. Calculate the Space to height ratio (S/H), lengthwise and width wise for layouts proposed in section (v)? **[2Marks]**

vii. Compare the answer of (vi) with the values given in the data sheet and propose a layout which comply with the space to height ratio given in data sheet? **[2Marks]**

viii. Calculate the number of lighting fixtures required for the reading area using 3X14 W, T5 Fluorescent luminaire? **[2Marks]**

ix. Calculate the number of lighting fixtures required for the reading area using 13 W downlight? **[2Marks]**

x. If the price of a 3X14 W, T5 Fluorescent luminaire is Rs 8000.00 and 13 W downlight is Rs 2500.00, What is your choice of luminaire for the Reading Area? **[1Marks]**

* *Relevant tables, data and charts are given in Page [15] of [16] and [16] of [16] for easy reference.*

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Rating factors (C_a) for Ambient air temperatures other than 30°c

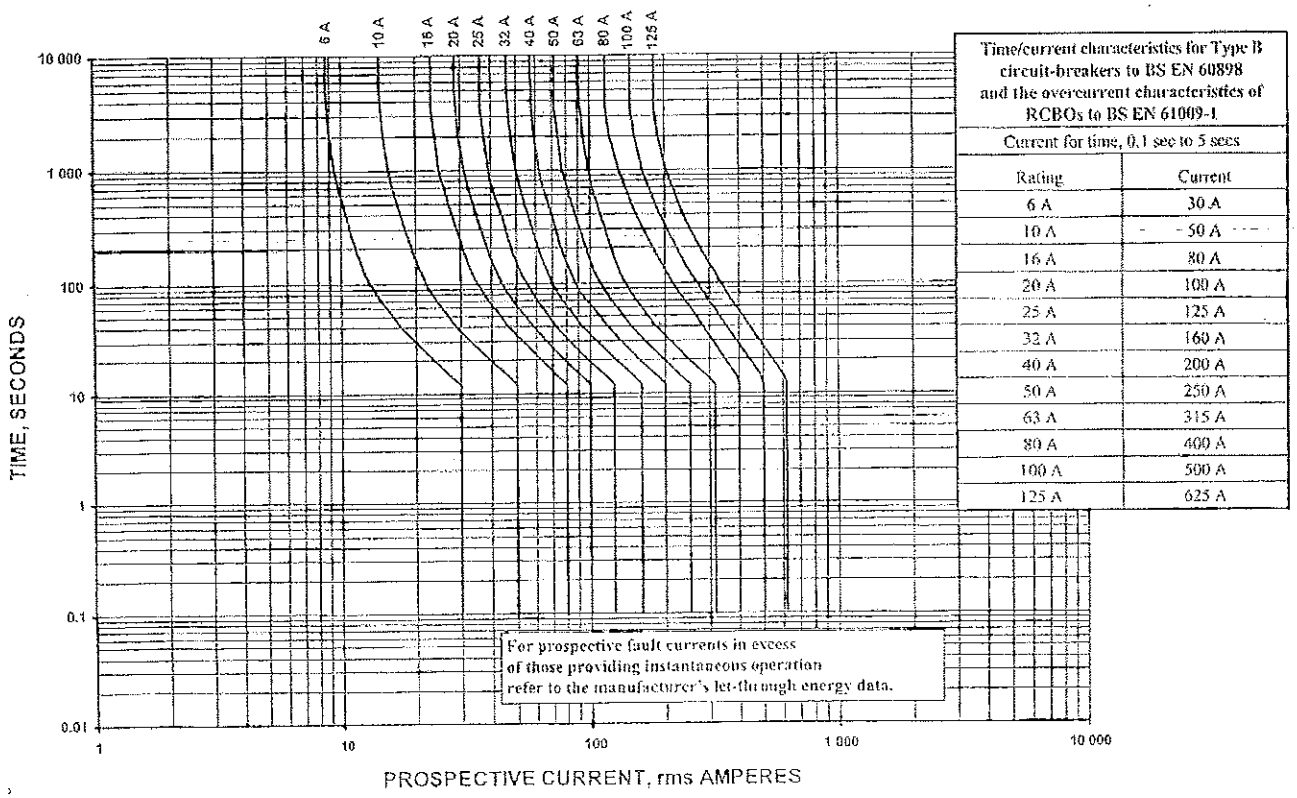
Ambient Temp. °C	Insulation 70 °C Thermoplastic	Insulation 90 °C Thermosetting
25	1.03	1.02
30	1.00	1.00
35	0.94	0.96
40	0.87	0.91

Rating factors (C_a) for ambient Ground temperatures other than 20°c

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	



Time/current characteristics for Type B circuit-breakers to BS EN 60898 and the overcurrent characteristics of RCBOs to BS EN 61009-1

Current for time, 0.1 sec to 5 secs

Rating	Current
6 A	30 A
10 A	50 A
16 A	80 A
20 A	100 A
25 A	125 A
32 A	160 A
40 A	200 A
50 A	250 A
63 A	315 A
80 A	400 A
100 A	500 A
125 A	625 A

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

Source: IEE wiring Regulations 16th edition

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

(COPPER CONDUCTORS)

CURRENT-CARRYING 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 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

Source: IEE wiring Regulations 18th edition

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 K.m/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°C thermoplastic insulated cables (COPPER CONDUCTORS)

Ambient temperature: 30 °C
Ground temperature: 20 °C
Conductor operating temperature: 70 °C

CURRENT-CARYING CAPACITY (amperes):

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-CARRYING 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)				
	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	Touching			Spaced by one diameter	
							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 16th edition

FACTORS FOR TRUNKING

Cable factors for Tunking

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

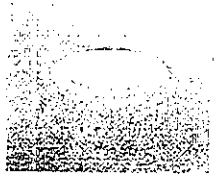
Conduit factors for runs incorporating bends.

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

CoreLine SlimDownlight

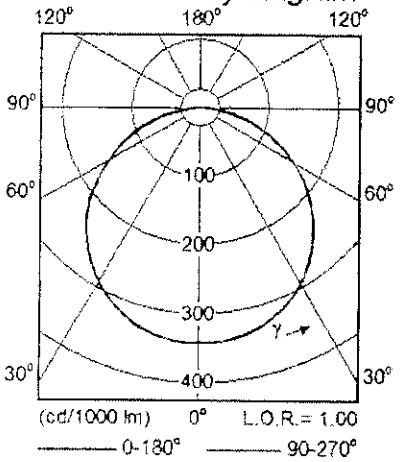
Luminaire	: DN135B D165 1xLED10S/830
Total Lamp Flux	: 1000 lm
Light Output Ratio	: 1.00
Luminous Flux	: 1000 lm
Power	: 13 W
HxD	: 0.03x0.17 m
Ballast	: -



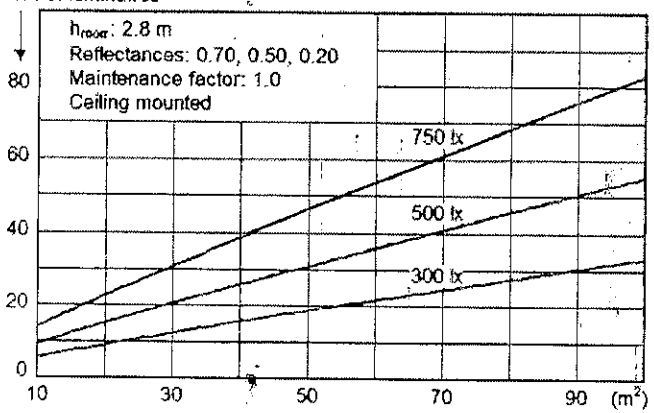
DN135B D165 1xLED10S/830

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	0.46
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	13928	14315
90.0	-	-	-

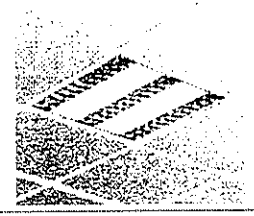
(cd/m2)

LVE2568600

2020-06-05

TBS165

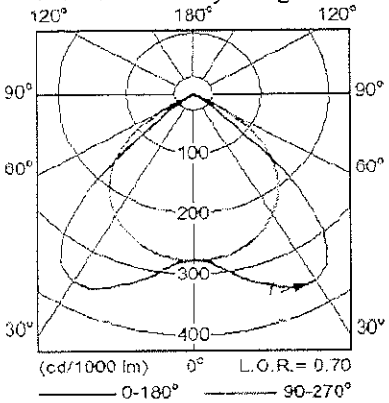
Luminaire	: TBS165 G 3xTL5-14W HFS C6
Total Lamp Flux	: 3600 lm
Light Output Ratio	: 0.70
Luminous Flux	: 2520 lm
Power	: 46 W
LxBxH	: 0.60x0.60x0.05 m
Ballast	: HF Standard



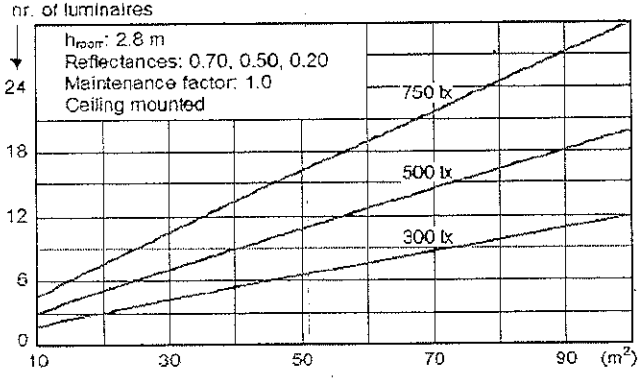
TBS165 G 3xTL5-14W HFS C6

3 x 1200 lm

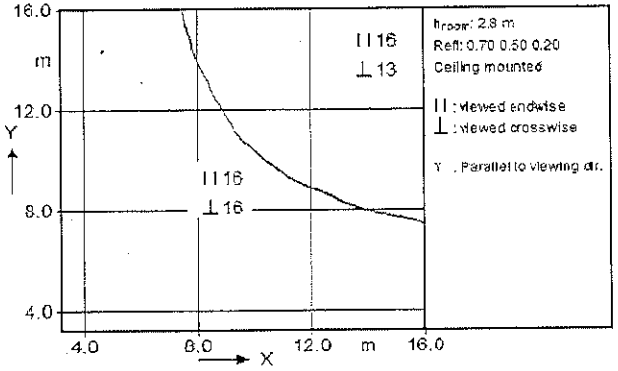
Polar intensity diagram



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 0.10 0.10	0.30 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	0.49	0.46	0.49	0.47	0.46	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	0.58	0.60	0.58	0.57
2.50	0.76	0.67	0.74	0.70	0.68	0.64	0.63	0.62	0.62	0.61	0.60
3.00	0.79	0.69	0.76	0.72	0.68	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	1275	2119
60.0	61	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