EXAMINATION: AUTHORISATION A

Paper II (Installation Technology)
Time Allowed - 3Hrs

February 2016

WRITE ALL YOUR WORK ON THE ANSWER BOOK PROVIDED. EVERY ANSWER SHOULD INCLUDE ALL WORKINGS, NECESSARY DIAGRAMS AND FORMULAE.

START EACH ANSWER ON A FRESH PAGE.

Choose any **FIVE** questions.

1. (a) Outline the IEE regulations relating to domestic ring circuits using BS1363 Socket-Outlets. **(5 marks)**

   (b) Draw neat separate circuit diagrams for the following circuits:

   i) four 13Amp socket outlets on the ring having two additional 13Amp socket outlets connected on the ring as spur.; **(7marks)**

   ii) a lighting circuit consisting of two luminaries controlled from three different locations; **(5marks)**

   iii) one 1.5kW water heater circuit. **(3marks)**

   For each circuit drawn show the wiring connections on the switch or socket outlet, the polarity, the size of cables used and the rating of circuit protective devices.

2. (a) Explain the importance of an earthing system in an electrical installation. **(4 marks)**

   (b) With reference to the IEE Regulations, which earthing system has been adopted locally? In your answer mention the other earthing systems used and clearly explain the locally adopted earthing system. **(6 marks)**

   (c) Draw a neat and well labelled diagram showing all the parts of a high breaking capacity fuse. **(6 marks)**

   (d) What is the purpose of supplementary bonding? **(4 marks)**

3. (a) When an electrical installation is finished a number of tests are carried out.

   List the sequence of tests required in the following:
   (i) before the supply is connected; **(5 marks)**
   (ii) with the supply connected. **(5 marks)**

   (b) For any three of the tests listed above, with the aid of figures explain how these are implemented. **(6 marks)**

   (c) List the instruments that are commonly used to test electrical installations. **(4 marks)**

4. (a) For the following installations IEE regulations recommend extra safeguards. In point form list and briefly explain the regulations to be observed and the type of accessories to be used:
   (i) circuits in bathrooms; **(6 marks)**
   (ii) swimming pool installations; **(4 marks)**
   (iii) temporary and construction site installations. For this particular installation it is important to include the testing period required and the precautions to be taken with regard to portable tools that are used on site. **(6 marks)**

   (b) What electrical equipment can be installed in zone 0 of a bathroom? What special precautions must be taken? **(4 marks)**

5. A 15 KW/240 Volts single-phase heating load is to be installed 10 m away from an SPN distribution board using PVC insulated single-core copper cables in plastic trunking.

   Circuit protection in the distribution board is by a BS 1361 fuse and an ambient temperature of 35 degrees Celsius is to be considered.

   Referring to the tables provided determine the following:

   (a) design current; **(5 marks)**
   (b) suitable fuse; **(5 marks)**
   (c) suitable conductor size; **(5 marks)**
   (d) circuit voltage drop. **(5 marks)**

6 a. The IEE Regulations make it clear that in the interest of safety in an electrical installation every circuit must be:

   (i) suitably controlled; **(1 mark)**
   (ii) protected against excess current; **(1 mark)**
   (iii) protected against earth leakage current. **(1 mark)**

   State in each case how this regulation is satisfied in an installation.

b. Explain the difference between:

   (i) an isolator and a circuit breaker; **(3 marks)**
   (ii) an M.C.B and a fuse; **(3 marks)**
   (iii) discrimination and fusing factor. **(3 marks)**

c. Make a neat sketch of an earth leakage circuit breaker. **(8 marks)**

END OF PAPER

TABLE 4D2B

VOLTAGE DROP (per ampere per metre):

Conductor operating temperature: 70 °C

Conductor cross-sectional area	Two-core cable, d.c.		Two-core cable, single-phase a.c.			Three- or four-core cable, three-phase a.c.			
1	2		3			4			
(mm²)	(mV/A/m)		(mV/A/m)			(mV/A/m)			
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		r	x		r	x	z
25	1.75	1.75	1.75	1.75	0.170	1.50	1.50	0.145	1.50
35	1.25	1.25	1.25	1.25	0.165	1.10	1.10	0.145	1.10
50	0.93	0.93	0.93	0.93	0.165	0.81	0.80	0.140	0.81
70	0.63	0.63	0.63	0.63	0.160	0.57	0.55	0.140	0.57
95	0.46	0.47	0.46	0.47	0.155	0.43	0.41	0.135	0.43
120	0.36	0.38	0.36	0.38	0.155	0.35	0.33	0.135	0.35
150	0.29	0.30	0.29	0.30	0.155	0.29	0.26	0.130	0.29
185	0.23	0.25	0.23	0.25	0.150	0.25	0.21	0.130	0.25
240	0.180	0.190	0.180	0.190	0.150	0.21	0.165	0.130	0.21
300	0.145	0.155	0.145	0.155	0.145	0.185	0.135	0.130	0.185
400	0.105	0.115	0.105	0.115	0.145	0.160	0.100	0.125	0.160

TABLE 4B1

Correction factors for groups of more than one circuit of single-core cables, or more than one multicore cable (to be applied to the corresponding current-carrying capacity for a single circuit in Tables 4D1 to 4D4, 4E1 to 4E4, 4F1 and 4F2, 4J1, 4K1 to 4K4, 4L1 to 4L4)**

Reference method of installation (see Table 4A1)		Correction factor (C_g) Number of circuits or multicore cables												
		2	3	4	5	6	7	8	9	10	12	14	16	18	20
Enclosed (Method 3 or 4) or bunched and clipped direct to a non-metallic surface (Method 1)		0.80	0.70	0.65	0.60	0.57	0.54	0.52	0.50	0.48	0.45	0.43	0.41	0.39	0.38
Single layer clipped to a non-metallic surface (Method 1)	Touching	0.85	0.79	0.75	0.73	0.72	0.72	0.71	0.70	-	-	-	-	-	-
	Spaced*	0.94	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Single layer *multicore* on a perforated metal cable tray, vertical or horizontal (Method 11)	Touching	0.86	0.81	0.77	0.75	0.74	0.73	0.73	0.72	0.71	0.70	-	-	-	-
	Spaced*#	0.91	0.89	0.88	0.87	0.87	-	-	-	-	-	-	-	-	-
Single layer *single-core* on a perforated metal cable tray, touching (Method 11)	Horizontal	0.90	0.85	-	-	-	-	-	-	-	-	-	-	-	-
	Vertical	0.85	-	-	-	-	-	-	-	-	-	-	-	-	-
Single layer multicore touching on ladder supports (Method 13)		0.86	0.82	0.80	0.79	0.78	0.78	0.78	0.77	-	-	-	-	-	-

* Spaced by a clearance between adjacent surfaces of at least one cable diameter (D_e). Where the horizontal clearance between adjacent cables exceeds 2 D_e no correction factor need be applied.

** When cables having differing conductor operating temperatures are grouped together, the current rating shall be based upon the lowest operating temperature of any cable in the group.

\- Correction factor not tabulated.

\# Not applicable to mineral insulated cables, see Table 4B2.

TABLE 4B2

Correction factors for mineral insulated cables installed on perforated tray, (to be applied to the corresponding current-carrying capacity for single circuits for Reference Method 11 in Table 4J1A)

Tray orientation	Arrangement of cables	Number of trays	Number of multicore cables or circuits					
			1	2	3	4	6	9
Horizontal	Multiconductor cables touching	1	1.0	0.90	0.80	0.80	0.75	0.75
Horizontal	Multiconductor cables spaced ‡	1	1.0	1.0	1.0	0.95	0.90	-
Vertical	Multiconductor cables touching	1	1.0	0.90	0.80	0.75	0.75	0.70
Vertical	Multiconductor cables spaced ‡	1	1.0	0.90	0.90	0.90	0.85	-
Horizontal	Single conductor cables trefoil separated ‡‡	1	1.0	1.0	0.95			
Vertical	Single conductor cables trefoil separated ‡‡	1	1.0	0.90	0.90			

‡ Spaced by a clearance between adjacent surfaces of at least one cable diameter (D_e).

‡‡ Separated by a clearance between adjacent surfaces of at least two cable diameters (2 D_e).

\- Correction factor not tabulated.

NOTES to Tables 4B1 and 4B2

1. The factors in the table are applicable to groups of cables all of one size. The value of current derived from application of the appropriate factors is the maximum current to be carried by any of the cables in the group.
2. If, due to known operating conditions, a cable is expected to carry not more than 30 % of its *grouped* rating, it may be ignored for the purpose of obtaining the rating factor for the rest of the group.
   For example, a group of N loaded cables would normally require a group reduction factor of C_g applied to the tabulated I_t. However, if M cables in the group carry loads which are not greater than 0.3 $C_g I_t$ amperes the other cables can be sized by using the group rating factor corresponding to (N-M) cables.
3. When cables having differing conductor operating temperatures are grouped together, the current rating shall be based on the lowest operating temperature of any cable in the group.
4. Where the horizontal clearance between adjacent cables exceeds 2 D_e, no correction factor need be applied.

TABLE 4C1
Correction factors for ambient temperature where protection is against short-circuit

NOTE: This table applies where the associated overcurrent protective device is intended to provide short-circuit protection only. Except where the device is a semi-enclosed fuse to BS 3036 the table also applies where the device is intended to provide overload protection.

Type of insulation	Operating temperature	Ambient temperature (°C)													
		25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
Thermosetting (rubber) (flexible cables only)	60 °C	1.04	1.0	0.91	0.82	0.71	0.58	0.41	-	-	-	-	-	-	-	-
Thermoplastic (General purpose pvc)	70 °C	1.03	1.0	0.94	0.87	0.79	0.71	0.61	0.50	0.35	-	-	-	-	-	-
Paper	80 °C	1.02	1.0	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45	0.32	-	-	-	-
Thermosetting (rubber)	85 °C	1.02	1.0	0.95	0.90	0.85	0.80	0.74	0.67	0.60	0.52	0.43	0.30	-	-	-
Thermoplastic (high temperature pvc)*	90 °C	1.03	1.0	0.97	0.94	0.91	0.87	0.84	0.80	0.76	0.71	0.61	0.50	0.35	-	-
Thermosetting	90 °C	1.02	1.0	0.96	0.91	0.87	0.82	0.76	0.71	0.65	0.58	0.50	0.41	0.29	-	-
Mineral	70 °C sheath	1.03	1.0	0.93	0.85	0.77	0.67	0.57	0.45	0.31	-	-	-	-	-	-
	105 °C sheath	1.02	1.0	0.96	0.92	0.88	0.84	0.80	0.75	0.70	0.65	0.60	0.54	0.47	0.40	0.32

NOTES:
1. Correction factors for flexible cords and for 85 °C and 180 °C thermosetting (rubber) insulated flexible cables are given in the relevant table of current-carrying capacity.
2. This table also applies when determining the current-carrying capacity of a cable.
3. * These factors are applicable only to ratings in columns 2 to 5 of Table 4D1A.

TABLE 4C2
Correction factors for ambient temperature where the overload protective device is a semi-enclosed fuse to BS 3036.

Type of insulation	Operating temperature	Ambient temperature (°C)													
		25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
Thermosetting (rubber) (flexible cables only)	60 °C	1.04	1.0	0.96	0.91	0.87	0.79	0.56	-	-	-	-	-	-	-	-
Thermoplastic (General purpose pvc)	70 °C	1.03	1.0	0.97	0.94	0.91	0.87	0.84	0.69	0.48	-	-	-	-	-	-
Paper	80 °C	1.02	1.0	0.97	0.95	0.92	0.90	0.87	0.84	0.76	0.62	0.43	-	-	-	-
Thermosetting (rubber)	85 °C	1.02	1.0	0.97	0.95	0.93	0.91	0.88	0.86	0.83	0.71	0.58	0.41	-	-	-
Thermoplastic (high temperature pvc)*	90 °C	1.03	1.0	0.97	0.94	0.91	0.87	0.84	0.80	0.76	0.72	0.68	0.63	0.49	-	-
Thermosetting	90 °C	1.02	1.0	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.79	0.69	0.56	0.39	-	-
Mineral: bare and exposed to touch or pvc covered	70 °C sheath	1.03	1.0	0.96	0.93	0.89	0.86	0.79	0.62	0.42	-	-	-	-	-	-
Mineral: bare and not exposed to touch	105 °C sheath	1.02	1.0	0.98	0.96	0.93	0.91	0.89	0.86	0.84	0.82	0.79	0.77	0.64	0.55	0.43

NOTES:
1. Correction factors for flexible cords and for 85 °C and 180 °C thermosetting (rubber) insulated flexible cables are given in the relevant table of current-carrying capacity.
2. * These factors are applicable only to ratings in columns 2 to 5 of Table 4D1A.

TABLE 4D2A
Multicore 70 °C thermoplastic (pvc) insulated and thermosetting insulated cables, non-armoured (COPPER CONDUCTORS)

COPPER CONDUCTORS

CURRENT-CARRYING CAPACITY (amperes):

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

Conductor cross-sectional area	Reference Method 4 (enclosed in an insulated wall, etc.)		Reference Method 3 (enclosed in conduit on a wall or ceiling, or in trunking)		Reference Method 1 (clipped direct)		Reference Method 11 (on a perforated cable tray) or Reference Method 13 (free air)	
	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.	1 two-core cable*, single-phase a.c. or d.c.	1 three-core cable* or 1 four-core cable, three-phase a.c.
1	2	3	4	5	6	7	8	9
(mm^2)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
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

NOTES:
1. **Where the conductor is to be protected by a semi-enclosed fuse to BS 3036, see item 6.2 of the preface to this appendix.**
2. Circular conductors are assumed for sizes up to and including 16 mm^2. Values for larger sizes relate to shaped conductors and may safely be applied to circular conductors.
3. * With or without a protective conductor.