Estimation and cost of material for wiring installation

Objectives: At the end of this lesson, you will be able to
- **state the points to be considered before taking up domestic wiring**
- **calculate the load(s) and select the number of sub(branch) circuits**
- **estimate the load in a circuit**
- **select proper cable size for branch main circuits and the supply system**
- **estimate and list out the accessories for given wiring installation.**

Points to be considered before taking up domestic wiring

The following points shall be noted particularly in respect of domestic dwellings.

Before starting the wiring installation, information should be exchanged between the owner of the building or architect and the local supply authority in respect of tariffs applicable, types of apparatus that may be connected under each tariff, requirement of space for installing meters, switches, service lines etc. and for the total load requirement of lights, fans and power.

While planning an installation, consideration should be given to the anticipated increase in the use of electricity for lighting, general purpose socket-outlet, kitchen, heating etc. Otherwise, the householder may be tempted to carry out extension of the installation himself or to rely upon the use of multiplug adaptors and long flexible cords, both of which are against the electric supply rules. Fundamentally safe installation may be rendered dangerous, if extended in this way.

Hence the National Electricity Code suggests the following schedule.

Number of points in branch circuits: The recommended yardstick for dwelling units for determining the number of points is given in Table 1.

Table 1

Number of points for dwelling units

Sl.No.	Description	Area of the main dwelling unit (m^2)				
		35	45	55	85	140
1	Light points	7	8	10	12	17
2	Ceiling fans (See NOTE below.)	2-2	3-2	4-3	5-4	7-5
3	5 A socket outlets	2	3	4	5	7
4	15 A socket outlets	–	1	2	3	4
5	Call bell (buzzer)	–	–	1	1	1

NOTE: **The figures in the table against Sl.No.2 indicate the recommended number of points and the number of fans. Example: For the main dwelling unit of $55m^2$, 4 points with 3 fans are recommended.**

Number of socket outlets

The recommended schedule of socket outlets for the various sub-units of a domestic dwelling are given in Table 2.

Table 2

Description	Number of socket outlets	
	6A	16A
Bedroom	2 to 3	1
Living room	2 to 3	2
Kitchen	1	2
Dining room	2	1
Garage	1	1
For refrigerator	–	1
For air-conditioner	–	1 (for each)
Verandah	1 per 10 m^2	1
Bathroom	1	1

Note that the BIS has changed the ampere specification of socket and plugs as 6 amps and 16 amps,whereas the earlier BIS references is for 5 amps and 15 amps. Further the manufacturers are yet to change their product specification from 5 A/15 A to 6 A/16 A. Hence the trainees are advised to use the new reference with due care for old reference also.

Electrical installation in a new building should normally begin immediately on the completion of the main structural building work. For conduit wiring system, the work should start before finishing work like plastering has begun. For surface wiring system, however, work should begin before final finishing work like white washing, painting etc.

Usually, no installation work should start until the building is reasonably weatherproof, but where electric wiring is to be concealed within the structures, the necessary conduits and ducts should be positioned after the shuttering is in place and before the concrete is poured, provision being made to protect conduits from damage. For this purpose, sufficient coordination shall be ensured amongst the concerned parties.

Sub(branch) circuits

Stated below are some of the important points from the above information sheet.

Sub-circuits may be divided into two groups

a Light and fan sub-circuits.

b Power sub-circuit.

Separate distribution boards shall be provided for light and power.

Each circuit shall be provided with a fuse in the phase wire and the neutral conductor shall be connected to a common link with disconnecting arrangement for testing.

The load on the light and fan sub- circuits should be restricted to 800 watts or ten points considering each light, fan and 6 amps sockets as points.

A minimum of two lighting sub-circuits shall be provided in each house so that in case of fault in one sub-circuit, the whole house is not plunged in total darkness.

The load on power circuits should be restricted to 3000 watts having not more than two socket outlets.

Estimation of load requirements

Electrical installation in domestic dwellings is basically designed to cater to light and fan loads and for electrical appliances and gadgets. In estimating the current to be carried by any branch circuit, unless the actual values are known, these shall be calculated based on the following recommended ratings.

Item	Recommended rating (in watts)
Incandescent lamps	60
Ceiling fans	60
Table fans	60
6 A, 3-pin socket-outlet points	100
Fluorescent tubes	
Length 600 mm	25
1200 mm	50
1500 mm	90
Power socket outlets (16 A)	1000

Example

Estimate the cost of material for wiring PVC channel for an office room having 2 lamps 1 fan one 6A socket outlet.

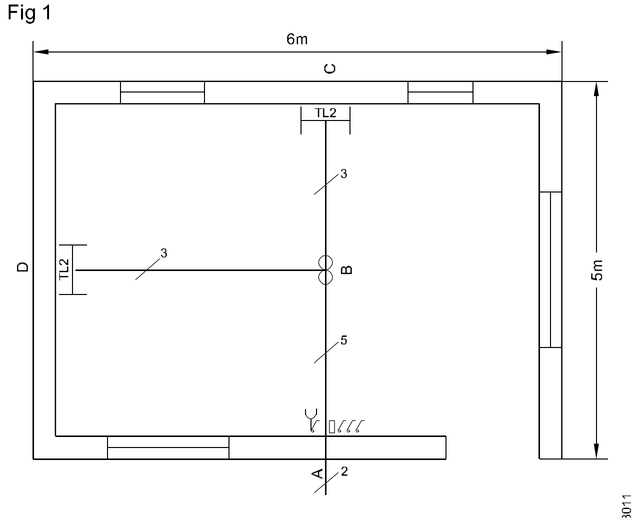
To estimate the cost of material the electrician has to follow these steps:

Type of wiring to be decided- PVC channel (casing and capping - given).

Position of the electrical points/Loads has to be decided as per the requirment.

Layout of the office has to be prepared (Fig 1).

Fig 1



LAYOUT DIAGRAM OF AN OFFICE ROOM

Total load to be calculated, In the given example

i) Tube 2nos x 50 W	= 100 W
ii) Fan1no x 60 W	= 60 W
iii) 6A socket 1 no	= 100 W
	260 W

circuit/connection diagram for the room has to be developed.

Based on the layout and circuit diagram calculate the length of PVC channel required.

1) Length of PVC channel

in Roof	= 5 +3 = 8m	
2) Vertical drops	= 0.5 +0.5 +2.0 = 3.0m	
Total	= 8+ 3.0	= 11.0 m
3) Add 10% tolerance	= 1.1 m	
	12.1 m	

7 Calculate the length of wire and size of wire based on layout, circuit diagram and load. In the given example,the total load is 260W the current taken by the total load are

$$I = \frac{p}{v \times \cos\theta} = \frac{260}{240 \times 0.8} = 1.35A$$

Hence PVC copper flexible 1sqmm wire is enough to this circuit/room. However since this wiring come in the catagory of commercial wiring, for safe-side, we can choose 1.5sq mm PVC insulated copper flexible wire.

Assume vertical drop is 0.5 m for tube lights and 2m for switch board then the length of wire required is

From A to B and vertical drop	= (2.5 +2)m x 5	= 22.5 m
From B to C and vertical drop	= (2.5 +0.5) m x 3	= 9m
From B to D vertical drop	= (3 +0.5)m x 3	=10.5m
total length	= 22.5 + 9 +10.5	= 42m
add 10% tolerance	= 42 + 4.2	= 46 m

The maximum number of wire runs in a PVC channel is 5 hence 19 mm x 10mm PVC channel may be used.

List of electrical accessories required with complete specification has to be prepared. Also calculate the cost of materials as per the present market rate.

Sl No	Accessories	Length	unit price	price
1	PVC channel 19 mm x10mm	12m		
2	1.5 sq mm PVC insulated copper flexible 650V	46 m		
3	Flush type SPT switch 6 A 250 V	4 No		
4	Flush type socket 6 A 250V	1No		
5	Wooden switch board 250mm x 150mm	1No		
6	Tube light fitting complete set 250V 4 feet 40W	2No		
7	Ceiling fan 250V, 1200 mm sweep	1 No		
8	electrcial fan regulator 250V , 60W	1No		
9	Wood screws 15 x 4mm, 25 x 5mm, 30 x6mm	25 Nos each		
10	PVC insulation tape 19mm width 9m length	1No		
11	Ceiling rose 3 plate 250 V , 6 A	3No		
Total	Cost of the material required			

In the same way trainees can be instructed to calculate the cost of materials required to wire up the following wiring in the PVC conduit.

1) godown wiring

2) Corridor wiring

3) hostel wiring

4) Tunnel wiring

Estimation for 3 phase domestic and commercial wiring

Objectives: At the end of this lesson you shall be able to
- **state specific rules related to 3-phase wiring installations**
- **estimate the wiring by load calculation, load distribution, layout diagram, wiring diagram, selection of cables, selection of conduit, calculation of conduit length, cable length, accessories required and the cost of wiring.**

3-phase wiring installation : The following provisions must be maintained for electrical installation:

1 Separate and distinct circuits for lighting, fan, heating and power wiring shall be kept.

2 All the wiring conductors shall be run at a height of 2.5 metres along the wall or on ceiling.

3 Proper distribution of load should be done at the main distribution load and also at the branch distribution board.

4 The load should be arranged in such a way that it is balanced on all the phases in case of 3-phase 4 wire system or poly phase system.

5 Distribution boards should be located at convenient points, preferably at the load centre.

6 The third pin of all the wall sockets must be earthed with minimum size of earth conductor of GI 14SWG or Aluminium 1.4mm^2

7 All the metal boards must be double earthed for medium and high voltage installation.

8 The phase, neutral and earth wire shall be distinctly marked at the main and branch distributed loads as per Indian Electricity Rule 32 of 1956.

Estimation of wiring

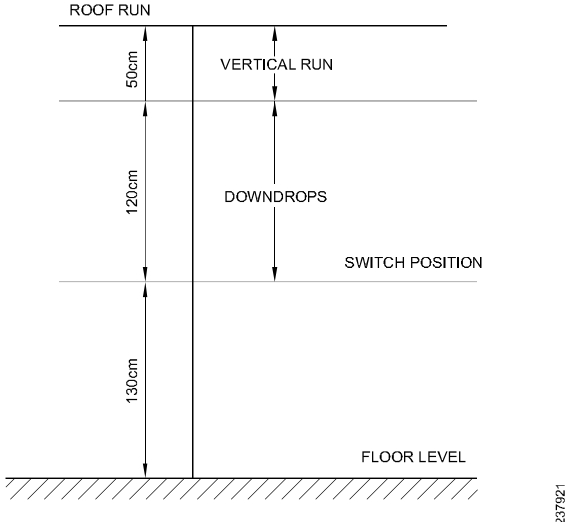
Fig 1 shows the vertical and down drops and switch position measurement from the ground level.

Study the consumer's requirement of light, fan and power points in each room (Fig 2).

Divide the load equally in 3-phases while doing so, as a requirement, the light and fan circuits of one room should be from the same phase.

In other words a single room should not get supply from two phases as this will pose a great danger to maintenance electrician and also separate line for individual phase is to be taken through the separate conduits. Clubbing of two or three phases through single conduit should be avoided.

Fig 1



VERTICAL RUN AND DOWN DROPS

Calculate the wattage of light, fan and power circuits in individual branch circuits of each phase. Then calculate the total connected load of the installation as well as current in each branch circuit.

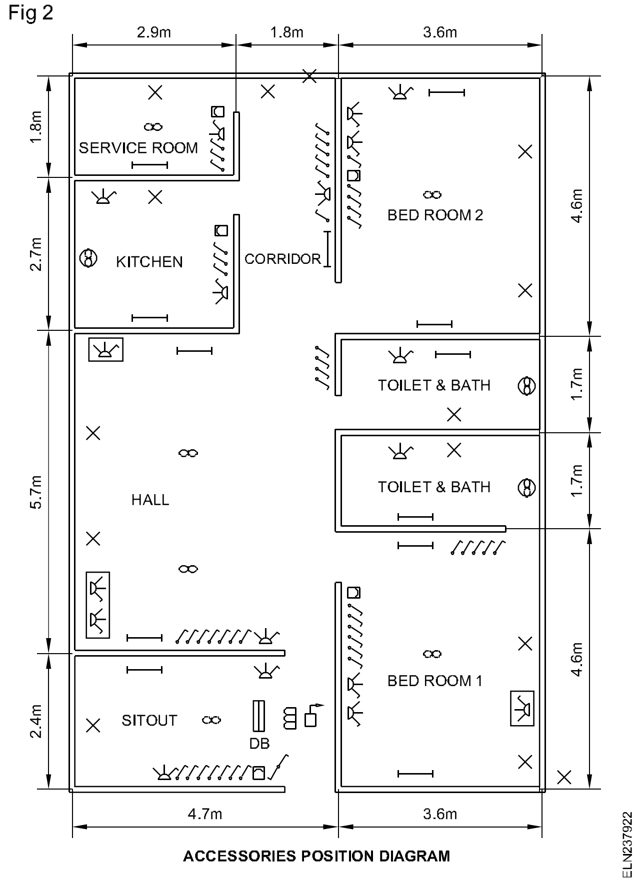
Refer to the position of accessories diagram and also the load division, then draw the layout diagram showing individual phase lines feeding to various rooms and exterior of the building. Fig 3 shows the layout diagram of phase L_1.

After finalizing the layout, the wiring diagram to be drawn.

Check the current capacity of each branch and select the size of the cable. After selecting the size of the cable and number of cables in each conduit run refer the PVC conduit table and select the size of the conduit (In the govt. installation CPWD has prescribed 19mm conduit as the minimum size to be used).

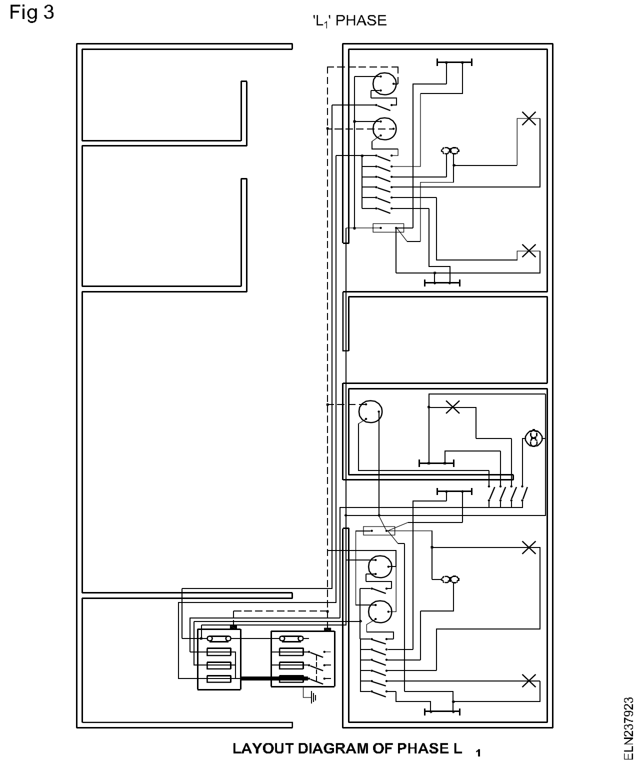
Required conduit length has to be calculated as per given method.

Fig 2



NE code recommends the horizontal run of cables should be at a height of 2.5m (250cm) and the height of switches from floor level should be 130cm. The example taken here for the roof height is 3m (300cm) from floor level. In all cases the dimension of the rooms should be available for estimating.

Fig 3



Vertical run : As such all vertical runs can be calculated as under (Refer Fig 4) for L_2 phase.

Length of selected conduit =

Roof height - (down drop + switch height) x No. of vertical runs

= 3m - (1.20m + 1.30m) x No. of vertical heights
= (3m- 2.5m) x No. of vertical heights
= 0.5m x No. of vertical heights (Eqn. 1)

The value 0.5m will change if there is difference in roof height and height of horizontal run of conduit changes.

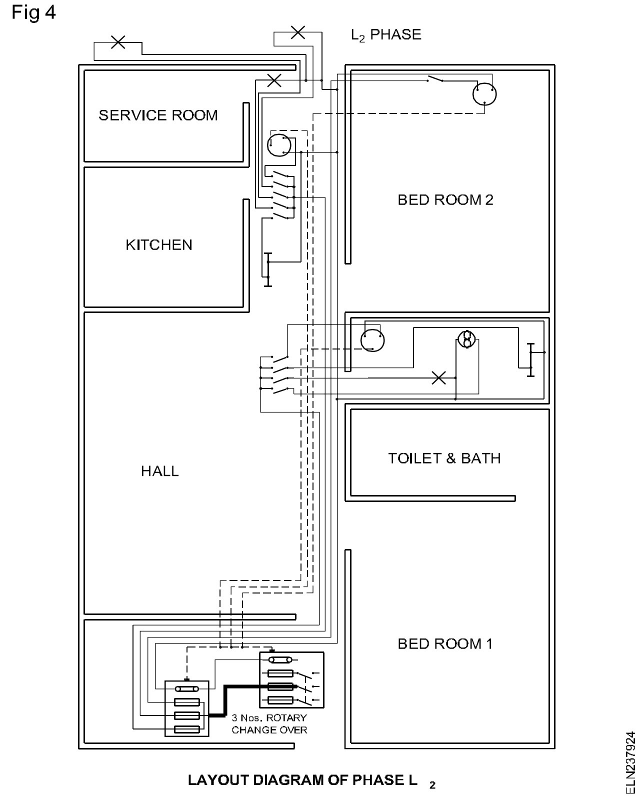
Length of conduit required for down drops

This could be calculated as under:

Length of selected conduit = Height of conduit in horizontal run - Switch position height x No. of down drops for switches

= (2.5m - 1.3m) x No. of down drops for switches
= 1.2m x No. of down drops to switches

Fig 4



Length of conduit required for roof runs

This could be calculated as under

Length of selected conduit = Sum of the actual length of roof run taken in each case.

For each size the total requirement is to be calculated.

Length of conduit required for horizontal run

Length of selected conduit = sum of the actual length of horizontal run taken in each case.

Length of conduit required for the distance between main switch and DB is to be calculated. In most of the cases wall is thickness has to be taken into account.

Example

(Refer the layout and wiring diagram with respect to phase L_1) In all cases except for main switch and DB the cable used is 1/1.12 copper cable and maximum number of cable it can accommodate in 19mm conduit is 7 cables. Hence PVC conduit of 19mm is chosen.

1 Length of conduit required for vertical run

Length for vertical run = 0.5m x No. of vertical height

A careful study of layout indicates there are 8 vertical height runs

= 0.5m x 8 = 4m of 19mm PVC conduit

2 Length of conduit required for down drops

Length of down drops = 1.2m x No. of down drops

A careful study of layout indicates there are 9 down drops = 1.2m x 9 = 10.8m

3 Length of conduit required for roof runs

Length of conduit = 2.35m + 2.35m + 2.35m + 2.35m + 1.45m + 0.9m = 9.75m

4 Length of conduit required for horizontal runs

Length of conduit = 4.7m + 3.6m + 1m + 1m + 1.2m + 4.7m + 2.4m + 1.35m + 1.2m + 2m + 2.35m + 5.7m + 2.9m + 2.9m + 1.35m + 2.7m + 2.5m + 1.45m + 1.8m + 1.45m = 48.25m

5 Length of conduit required for main switch and DB

If individual phase line is to be drawn through 19mm PVC conduit will be sufficient on the other hand if all three phase cables to be drawn through single pipe, the requirement to be calculated separately.

Assuming individual phases will be drawn through individual conduits the 19mm PVC conduit will be sufficient to draw two cables of sizes upto 1/2.8 or 7/1.06 aluminium and copper cables respectively.

Length of conduit required for the distance between main switch and DB : Length of conduit = wall thickness + allowance for connection = 0.36m + 0.5m + 0.5m = 1.36m

Total length of PVC conduit 19mm for wiring phase L_1 as per layout and wiring diagram

= Vertical run + down drops + roof runs + horizontal runs + switch DB
= 4m + 10.8m + 9.75m + 48.25m + 1.36m = 74.16 m

Assuming 10% wastage, the total required length of 19mm PVC conduit will be 73.81m + 7.3m = 81.11m or say 80m

Calculation of length of cable required for wiring phase L_1: For calculating the length of cable accurately the layout and wiring diagrams should be referred. Selected cable in this case is 1 sq.mm copper cable.

Cable required = For outside runs ((L_1 + L_2 + L_3 + L_4) down drop + Horizontal run + switch board to outside wall (thickness of wall)
+ DB to switch board (DD + HR + DD)
+ Switch board to L_5 + (DD + HR)
+ L_5 to F_1 (VR + RR)
+ L_5 to L_6 L_7 (HR + HR)
+ DB to SB_2 (DD + HR + DD)
+ SB_2 to L_9 (DD + HR)
+ L_9 to F_2 (VR + RR)
+ SB_2 to S_3, S_4 (DD + HR + DD)
+ L_9 to L_{10} (HR)
+ L_{10} junction to F_3 (VR + RR)
+ L_{10} junction to L_{11} (HR)
+ S_3, S_4 to S_5 (DD + HR + DD)
+ From DB to S_6 (DD + HR +DD)
+ From S_6 to L_{12} (DD + HR)
+ L_{12} to F_5 (HR)
+ S_6 to F_4 (DD + HR + DD)
+ S_6 to L_{13} (DD + HR)
+ S_6 to S_8 (DD + HR + DD)
+ S_6 to S_7 (DD + HR + DD)
+ S_8 to F_6 (DD + RR)
+ F_6 to L_{15}
+ F_6 to L_{14}

= +	(3.6m + 1m)2 + (4.7m + 1m)3	26.3m
+	(0.36M+ 0.5m) x 5 + (1.2m + 3m + 1.2m)2	15.1m
+	(1.2m + 3m + 1.2m)2	10.8m
+	(1.2m + 4m + 1.2m)5	32.0m
+	(0.5m + 2.35m)2	5.7m
+	(1.2m + 2.35m)3 + 2.35m x 2	15.35m
+	(1.2m + m2 + 1.2m)2	8.8m
+	(1.2m + 4m + 2m)6	43.2m
+	(0.5m + 2.35m)2	5.7m
+	(1.2m + 1.5m)2	5.4m
+	(1.2m + 4m + 2m + 1.2m)2	14.8m
+	2m x 4	8.0m
+	(0.5m + 2.35m)2	5.7m
+	(2m + 2.5m)2	9.0m
+	(1.2m + 5m + 1.2m)2	14.8m

+	(1.2m + 4m + 5.7m + 2.9m + 2m + 1.2m)2	34.0m
+	(1.2m + 1.4m + 1.5m)3	12.3m
+	(1.5m + 1.35m)2	5.7m
+	(1.35m x 3m) + (1.35m x 2m)	6.75m
+	(1.35m + 1.45m + 1.2m)2	8.00m
+	(1.2m + 1.4m + 0.9m + 1.2m)2	9.4m
+	(1.2m + 1.45m + 1.2m)2	7.7m
+	(1.2m + 1.45m)3	7.95m
+	0.9m x 2m	1.8m
+	0.9m x 2m	1.8m
		325.95m
	Add 10%	32.59m
	Say 360m of 1 sq.mm copper	358.54m

The length of the cable required for power circuit in phase L_1. The cable chosen is 4 sq.mm copper cable which can carry 24 amps

Total length of cable = (1.2m + 0.36m + 2.4m + 3.6m + 2.4m + 1.2m)2
= 11.16m x 2
= 22.32m

Add 10% for wastage = 2.2m

24.52m

Say 25m of 4 sq.mm copper cable is required.

In the same way for the circuits in L_2 and L_3 phases should be calculated. After the list of accessories for entire wiring is prepared the cost of the accessories could be obtained from any local electrical dealer.

Instructor is requested to discuss with the trainees about the mandays required to complete the job alongwith the cost of labour.

Total cost of wiring comprisis of following components.

Total cost of wiring = cost of the accessories
+ cost of cable
+ cost of conduit
+ cost of hardware items
+ labour cost

Estimation of cost for workshop wiring

Objectives: At the end of this lesson you shall be able to
- **calculate the full load current and size of cables**
- **estimate the cost for workshop wiring**
- **tabulate the material required.**

The trainees can be instructed to estimate the cost of materials for the workshop wiring. Some of the guidance are given below for the trainees and instructor referance.

A sample requirement is given below for trainee's reference

1 One 5HP, 415V 3 phase motor

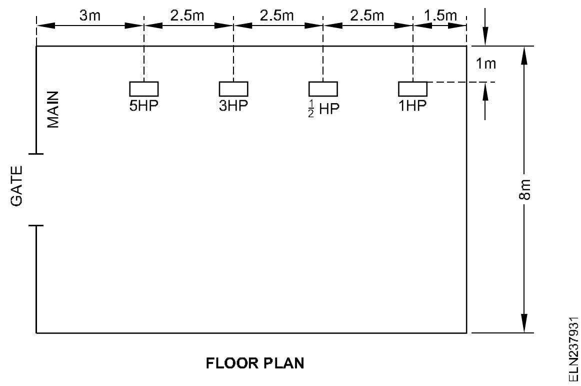
2 One 3HP, 415V 3 phase motor

3 One ½ HP, 240V 1 phase motor

4 One 1HP, 415V 3 phase motor

The motors are to be arranged in row (Fig 1).

Fig 1



The main switch, motor switch and starters are to be mounted at a height of not more than 1.5m from the ground level and the height of horizontal run from ground level will be 2.5 m.

Calculation for the size of cable:

Assuming the motor efficiency to be 85% and the power factor to be 0.8 for all the motors and the supply voltage is 400V.

$$\text{FL current of 5HP motor} = \frac{5 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 7.8\text{A}$$

$$\text{FL current of 3HP motor} = \frac{3 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 4.68\text{ A}$$

$$\text{FL current of ½ HP motor} = \frac{0.5 \times 735.5}{240 \times 0.85 \times 0.8} = 2.25\text{ A}$$

$$\text{FL current of 1HP motor} = \frac{1 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 1.56 \text{ A}$$

The main switch and the cable from meter to main switch should be capable of handling starting current of one motor of high rating plus full load current of the all other motors.

i.e, 15.6+4.68+2.35+1.56 = 24.19A

Assuming the starting current of each motor will be two times of their full load current Table 1 gives cable size of each motors to be installed for guidance.

Table - 1

Sl. No.	Motor	FL current I_L in Amp	Starting current $I_S = 2I_L$ in Amp	Recommended cable size
1	5HP motor	7.5	15.6	2.0mm^2 coppere conductor cable (17A) or 2.5mm^2 aluminium conductor cable (16A)
2	3HP motor	4.68	9.36	2.0mm^2 copper conductor cable (17A)
3	1/2 HP motor	2.25	4.5	1.0mm^2 copper conductor cable (11A) minimum recommended cable
4	1HP motor	1.56	3.12	1.0mm^2 copper conductor cable (11A) minimum recommended cable

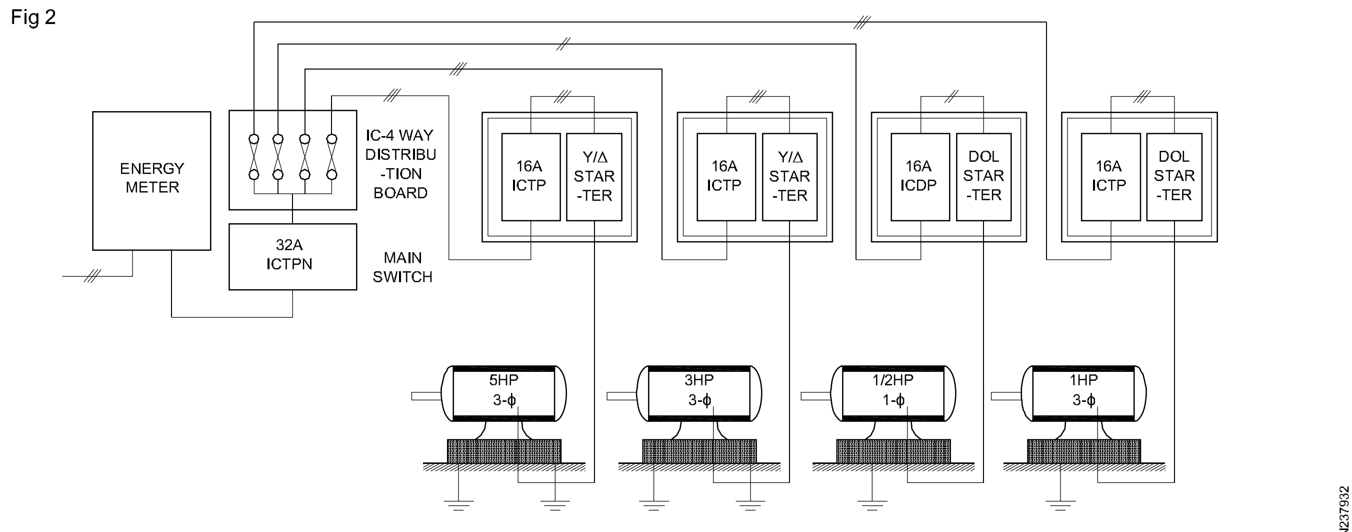
The type and gauge of cable shall be selected by referring the table - 1

Some guidance are given bleow to select the suitable switches and distribution board for trainees reference.

- A 32A, 415V ICTP switch with fuses can be used as main switch.
- 16A, 415V, ICTP switches with fuses can be used for 5HP, 3HP, & 1HP motors.
- 16A, 240V, ICDP switch with fuses can be used for ½ HP motor.
- 415V, 4 way, 16A per way IC distribution board with neutral link can be used for power distribution.

The single typical line diagram of power wirings (Fig.2)

Fig 2



SINGLE LINE DIAGRAM OF POWER WIRING IN WORKSHOP

Calculation for the sizes and length of conduit:

19mm heavy gauge conduit should be used for 3 cable runs and 24.4 mm heavy gauge conduits should be used for 6 cable runs.

- 19 mm heavy gauge conduit

Length from main board to 5HP motor starter = 1+1+3+1 = 6.0m

Length from main board to 3HP motor starter = 1+1+5.5+1 = 8.5m