

Candidate Code No	
<b>For Board Use Only</b>	
Result	Result
Date	Date
Int	Int

## **ELECTRICAL WORKERS REGISTRATION BOARD**

### **ELECTRICIAN'S THEORY EXAMINATION**

**22 NOVEMBER 2003**

### **QUESTION AND ANSWER BOOKLET**

Time Allowed: Three hours

#### **INSTRUCTIONS – READ CAREFULLY**

You have 10 minutes to read this paper but do not start writing until you are told to do so by the supervisor.

Write your Candidate Code Number in the box provided above. Your name must NOT appear.

**The minimum pass mark for this examination is 60 marks.**

- Answer** - All questions in Section 1  
 - Any FIVE questions in Section 2.  
 (if you answer all questions in section 2, strike out the question you do not want marked)

Drawing instruments may be used when diagrams are required. Marks are allocated on the basis of correctness. Approved calculators may be used. However, for calculation questions all workings must be shown to gain full marks.

**Warning** – You could get 0 marks for any question, or part of a question, if you show anything hazardous or dangerous in your answer.

**Candidates are not permitted to use any Act, Regulation, Standard, Code, Handbook or other reference text in this examination.**

**YOU MUST HAND YOUR ANSWER BOOK TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**

**(turn over)**

## SECTION 1

(Answer all questions in this section)

### Question 1

Each part of Question 1 is worth 1 mark

- (a) Sketch the circuit symbol for a photo diode.
- (b) Other than environmental, list **TWO** factors that determine the cross-sectional area of a cable used to supply a three-phase induction motor .
- (1) \_\_\_\_\_ (1/2 mark)
- (2) \_\_\_\_\_ (1/2 mark)
- (c) Why are auto transformers **NOT** to be used to supply extra-low voltage electric toys?
- \_\_\_\_\_
- \_\_\_\_\_
- (d) Why must portable RCDs or isolating transformers be placed as close as practical to the socket outlet when used to supply hand-held power tools in outdoor or damp situations?
- \_\_\_\_\_
- \_\_\_\_\_
- (e) What is the recommended ratio to ensure a safe working angle when using a ladder?
- \_\_\_\_\_

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(f) Describe an acceptable method-of discharging a capacitor before disconnection from a circuit that has already been isolated.

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(g) State **TWO** reasons for using reduced voltage starting for a three-phase induction motor.

(1) \_\_\_\_\_ (1/2 mark)

(2) \_\_\_\_\_ (1/2 mark)

(h) What effect does an increase in load have on the efficiency of a lightly loaded three-phase induction motor?

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(i) What type of winding arrangement is most likely in a three-phase power transformer that has three connections to its primary and four connections to its secondary?

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(j) List **TWO** personal hazards associated with arcing.

(1) \_\_\_\_\_ (1/2 mark)

(2) \_\_\_\_\_ (1/2 mark)

(k) List **TWO** examples of prime movers used to drive large alternators.

(1) \_\_\_\_\_ (1/2 mark)

(2) \_\_\_\_\_ (1/2 mark)

**(turn over)**

(l) Name **TWO** types of fire extinguishers suitable for use on fires on or near live electrical equipment.

(1) \_\_\_\_\_

(2) \_\_\_\_\_

(m) State **TWO** reasons for earthing the metal frame of a Class I electrical appliance.

(1) \_\_\_\_\_

(2) \_\_\_\_\_

(n) What is meant by the term **peak inverse voltage** as applied to semiconductor devices?

\_\_\_\_\_  
\_\_\_\_\_

(o) Why is a three-phase induction motor more efficient than the equivalent size single-phase induction motor?

\_\_\_\_\_  
\_\_\_\_\_

(p) Sketch the circuit symbols for EACH of the following:

(i) Triac

(ii) Zener diode.

**(turn over)**

- (q) Give an application where a three-phase motor would require phase reversal protection.

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- (r) How is the voltage regulation of a power transformer achieved with changing loads?

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- (s) If a three-phase motor has six terminals and windings rated at 230V how must it be connected to a 400V three-phase supply?

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- (t) What precaution must be taken before disconnecting metering from a CT in a live circuit that cannot be isolated.

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## Question 2

- (a) List the FOUR prescribed tests/checks required to ensure electrical safety when a single-phase socket outlet and circuit wiring has been installed. (2 marks)

- (1) \_\_\_\_\_  
(2) \_\_\_\_\_  
(3) \_\_\_\_\_  
(4) \_\_\_\_\_

- (b) Describe in detail how each of the tests/checks in (a) should be carried out. Include in your answer the type of meter used and any minimum or maximum values that may apply. (8 marks)

- (1) \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
(2) \_\_\_\_\_  
\_\_\_\_\_  
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(3) \_\_\_\_\_  
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(4) \_\_\_\_\_  
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\_\_\_\_\_

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### Question 3

A three-phase, 400 V, star-connected lathe draws 27 A from the supply and is protected by 32 A motor-rated fuses. A fault of  $14 \Omega$  has occurred between one line and the machine frame while the machine was operating. Assume the earth continuity resistance is  $0 \Omega$ .

- (a) Calculate the total current in the faulty line

(2 marks)

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- (b) Show by calculation the effect, if any, that this fault would have on circuit protection.

(3 marks)

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**Question 4 continued**

(ii) Short circuit

(3 marks)

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## **SECTION 2**

(Answer any **FIVE** questions in this section. If you answer all questions, please strike out the question you do not want marked)

### **Question 5**

(a) Sketch and label a simple diagram to represent an MEN distribution system showing:

- A delta-star-connected 11 kV/400 V supply transformer including output lines
- A single-phase consumer installation including main switch, and neutral and earth bar connections
- A three-phase consumer installation including main switch, and neutral and earth bar connections
- All earthing arrangements.

(5 marks)

**(turn over)**

**Question 5 continued**

(b) List **TWO** advantages of a three-phase MEN system. (2 marks)

(1) \_\_\_\_\_

(2) \_\_\_\_\_

(c) Explain the meaning of the term **electrically safe**. (3 marks)

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## Question 6

- (a) Sketch and label a circuit diagram of a three-phase full wave rectifier circuit supplied from a delta-delta connected supply transformer. Indicate load polarity.

(4 marks)

- (b) Sketch the output waveform for one cycle of the circuit in (a).

(2 marks)

**(turn over)**

**Question 6 continued**

(c) State **TWO** components that may be used as filters in rectifier circuits. (1 mark)

(1) \_\_\_\_\_

(2) \_\_\_\_\_

(d) Explain each of the following faults in a switch-start fluorescent fitting:

(i) The tube does not strike and ends are glowing (1 mark)

\_\_\_\_\_  
\_\_\_\_\_

(ii) The tube attempts to strike but fails to maintain conduction. (1 mark)

\_\_\_\_\_  
\_\_\_\_\_

(iii) The tube ends are blackened and the light output is low. (1 mark)

\_\_\_\_\_  
\_\_\_\_\_

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### Question 7

(a) Three resistive loads of 12 kW, 18 kW and 28 kW are star-connected to a 400 V, three-phase, four-wire supply.

(i) Calculate the current in **EACH** line.

(2 marks)

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(ii) Determine the current in the neutral.

(3 marks)

(iii) Calculate the total power dissipated.

(2 marks)

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**Question 7 continued**

- (b) Briefly describe what would happen to the phase voltages across the load resistors if the neutral became disconnected from the star point. Calculations are not required.

(2 marks)

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- (c) Why is it desirable to balance the single-phase sub-circuits in a three-phase installation?

(1 mark)

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**Question 8**

(a) Explain how each of the following conditions effects the operation and performance of a fully loaded three-phase squirrel cage induction motor.

(i) A small mechanical overload for a long period of time. (1 mark)

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(ii) A mechanical overload that exceeds the motor's pullout torque. (1 mark)

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(iii) Under voltage (1 mark)

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(iv) If one motor winding open circuits (1 mark)

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## Question 9

- (a) Sketch and label a circuit diagram to show how a current-operated relay and current transformer (CT) can be connected in a circuit to provide protection against excess current.

Include in your diagram the following components:

- CT
- Load
- Relay contacts
- Relay coil.

(3 marks)

- (b) Explain why there should be no fuses on the secondary of the CT in (a).  
(2 marks)

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### Question 9 continued

- (c) State **TWO** common secondary current ratings used for CTs. (1 mark)

(1) \_\_\_\_\_

(2) \_\_\_\_\_

- (d) Sketch and label a circuit diagram to show how a voltage transformer (VT) can be connected in a circuit to supply a reduced voltage to an indicating voltmeter.

Include in your diagram the following components:

- VT
- Load
- Meter
- Meter protection.

(3 marks)

- (e) State the common secondary voltage rating of voltage transformers when supplied at their full primary voltage. (1 mark)

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**(turn over)**

### Question 10

- (a) Complete Figure 1 below to show how an on/off switch and a reversing switch can be used to control a universal motor in a power tool. (5 marks)

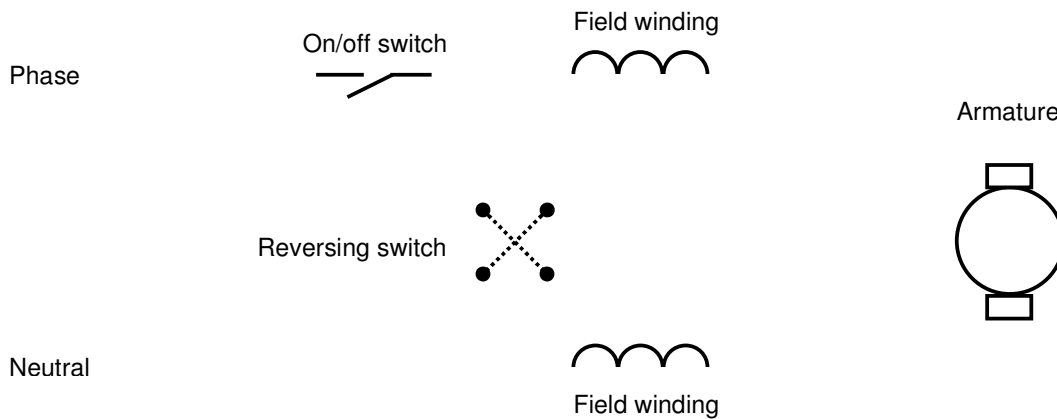


Figure 1

- (b) Give **FOUR** reasons why universal motors are more suitable than single-phase induction motors for use in portable power tools. (2 marks)

- (1) \_\_\_\_\_
- (2) \_\_\_\_\_
- (3) \_\_\_\_\_
- (4) \_\_\_\_\_

(turn over)

**Question 10 continued**

- (c) Explain how HRC motor-rated fuse links provide backup protection for the thermal overloads in a DOL starter supplying a three-phase electric motor in the event of a short-circuit.

(3 marks)

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**For Candidate's Use**

In the box, write the number of **EXTRA** sheets you have used. Write **NIL** if you have not used any

<b>For Examiner's Use Only</b>		
<b>Questions Answered</b>	<b>Marks</b>	
<b>1</b>		
<b>2</b>		
<b>3</b>		
<b>4</b>		
<b>5</b>		
<b>6</b>		
<b>7</b>		
<b>8</b>		
<b>9</b>		
<b>10</b>		
<b>TOTAL</b>		