



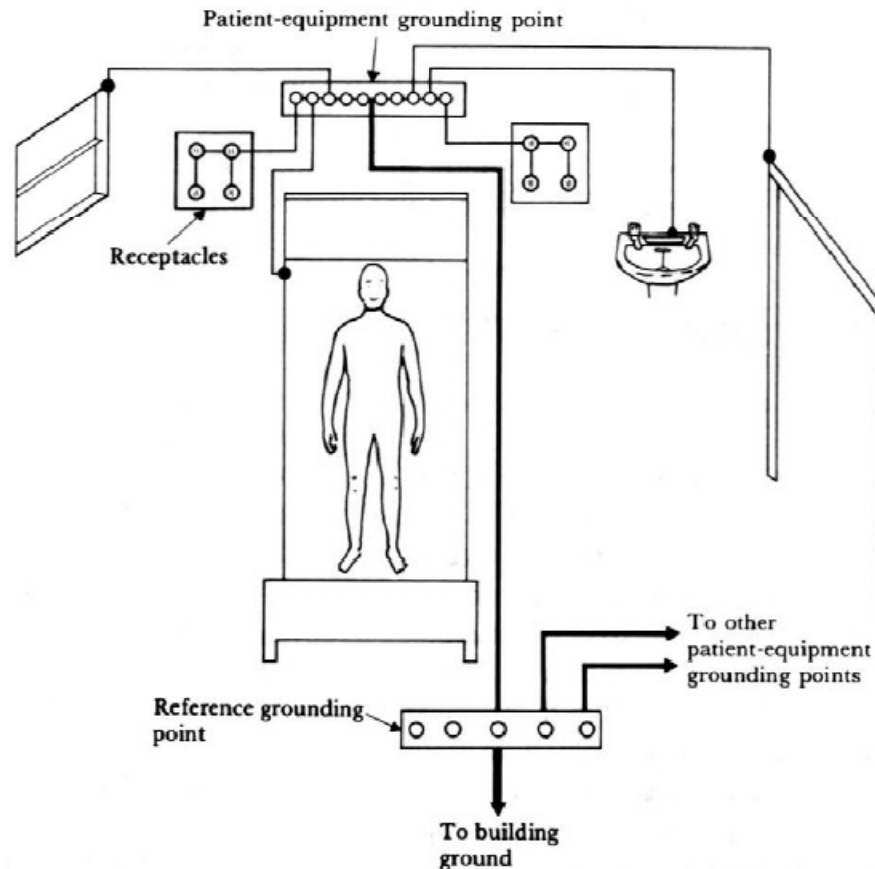
## Exam With Model Answer

Answer the following questions.

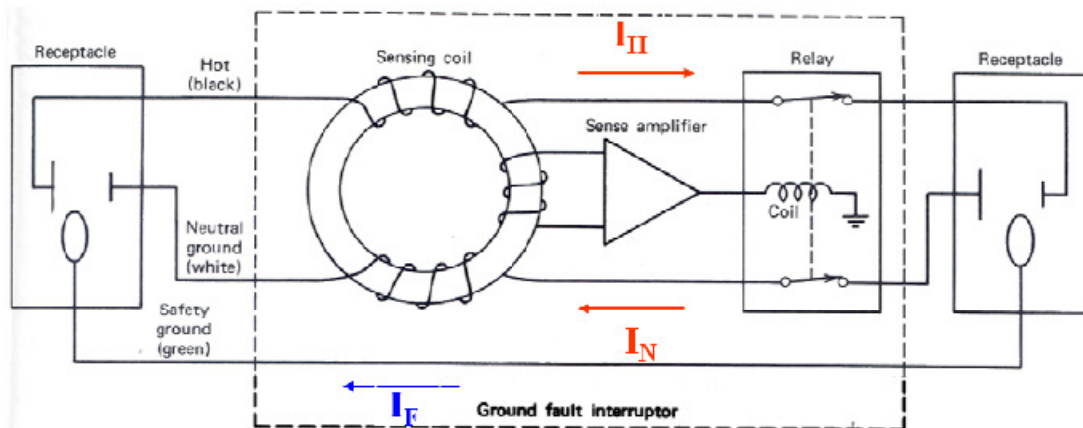
**Question (1): Draw (mention each thing in the drawing)**

[20 Marks]

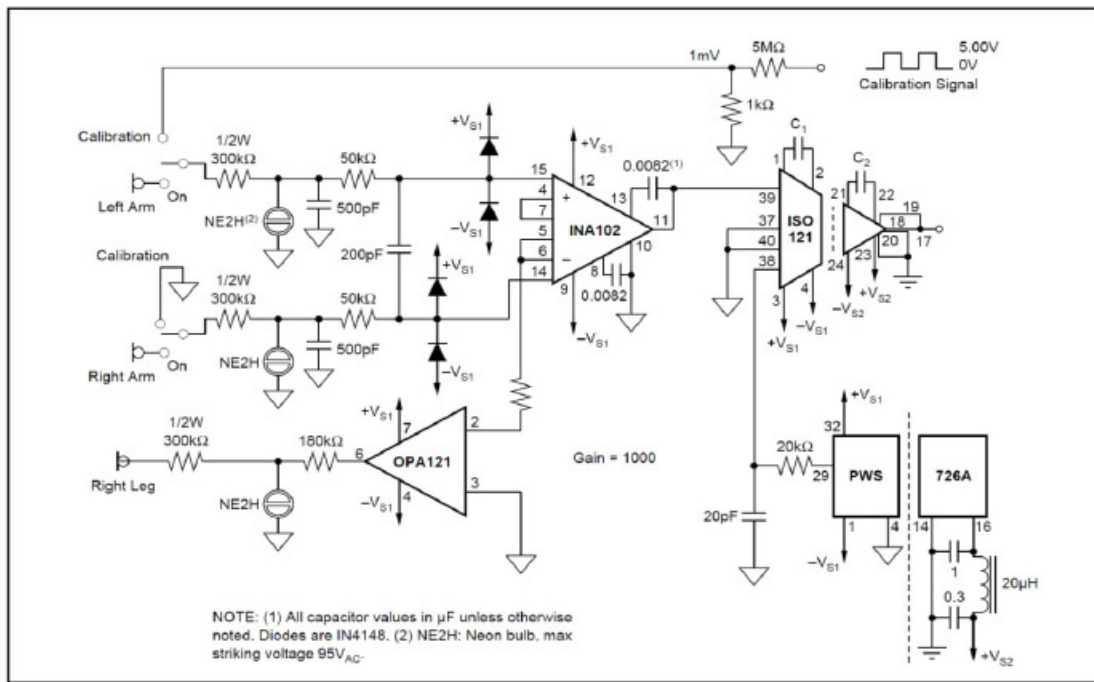
a) Equipotential grounding system.



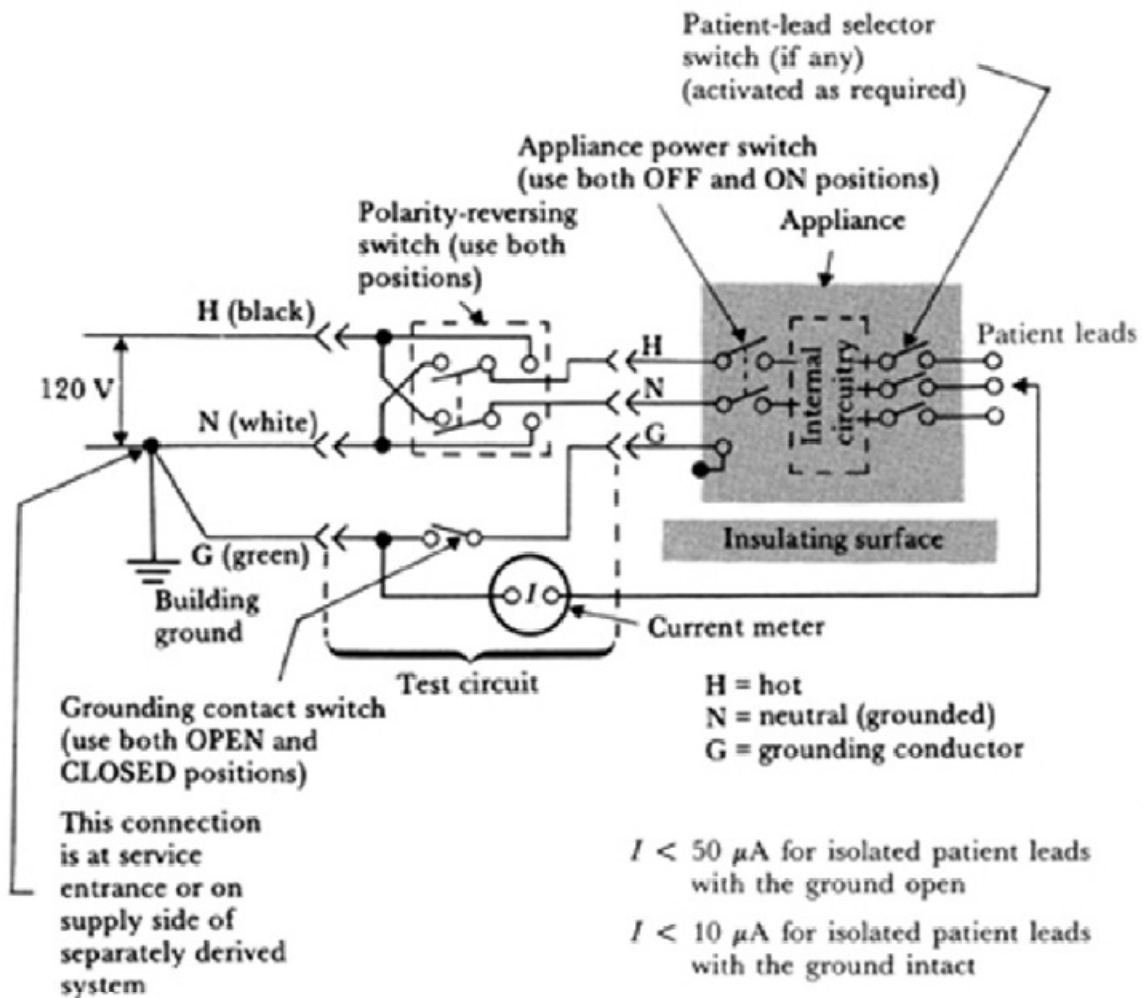
b) Ground fault interrupter circuit.



**c) Driven right leg with isolated input ECG amplifier.**



**d) Test for leakage current from patient leads to ground.**



**Question (2):**

**[10 Marks]**




**Below is a list of basic safety recommendations for use in hospitals and other clinical settings. Give a rationale for each precaution.**

<b>SAFETY RECOMMENDATION</b>	<b>RATIONALE (REASON)</b>
AVOID GROUNDING THE PATIENT	<i>Patient less likely to become part of a completed circuit.</i>
GROUND ALL ELECTRICAL EQUIPMENT NEAR THE PATIENT	<i>If faulty equipment becomes live, the current will follow the low resistance earth wire to the ground.</i>
KEEP ELECTRICAL EQUIPMENT OUT OF REACH OF THE PATIENT IF POSSIBLE.	<i>They cannot change settings; avoids contact with equipment should it become faulty; exceptions: work own monitor in coronary care, administer own pain killers in oncology ward.</i>
IF A FUSE BLOWS, CALL AN ELECTRICIAN TO REPLACE IT. . <i>Reinforce circuit breaker. Not the same as home → in hospital don't click back on.</i>	<i>Blown fuse indicates a fault, therefore repair fault, don't not just replace fuse (clinical setting)</i>
ONLY AN ELECTRICIAN MAY REPAIR ELECTRICAL WIRING.	<i>By law</i>
ALL ELECTRICAL EQUIPMENT SHOULD BE CHECKED AND LABELLED ON A REGULAR BASIS	<i>By law; tag testing; check insulation; check exposed wires of cords etc.</i>

**Question (3):**

**[10 Marks]**

**Complete equipment and patient circuit classification.**

	Description	Classification	Symbol
Equipment construction	Earthed	Class I	No symbol
	Doubled Insulated	Class II	
	Extra low voltage	Class III	No symbol
Patient circuit	Cardiac Protected (formerly Class A)	Type CF	
	Body protected (formerly Class B)	Type BF	
	Unprotected (formerly Class C)	Type B	No symbol

**Question (4):****[20 Marks]**

If the patient is lying on an electrically operated bed in ICU, the ground connection from the wall plug to the bed is faulty. The patient is equipped with a pacing catheter connected to a small battery operated pacemaker; the patient is connected to ECG monitor. The right leg ECG electrode is connected to the hospital grounding system through the monitor. Assume that attendant comes to bedside to adjust the pacing catheter connections and without thinking simultaneously touches the pacemaker terminals and bedrail. If the attendant's resistance is  $500 \Omega$ , the patient's resistance is  $500 \Omega$ , and the differential voltage between the attendant's right hand and the patient's right leg is 200 mV. Answer the following questions.

a) **Does current pass through the attendant?**

Yes.

b) **If so, how much?**

200  $\mu\text{A}$

c) **Is this a macroshock or microshock situation for the attendant?**

Macroshock situation.

d) **Is the attendant most probably shocked (above sensation)?**

No.

e) **Is the attendant most probably electrocuted (killed) by modern standards?**

No.

f) **Does current pass through the patient?**

Yes.

g) **If so, how much?**

200  $\mu\text{A}$

h) **Is this a macroshock or microshock situation for the patient?**

Microshock situation.

i) **Is the patient most probably shocked (above sensation)?**

Yes.

j) **Is the patient most probably electrocuted (killed) by modern standards?**

Yes.

*With best wishes*

*Dr. Eng. Wael Abdel-Rahman Mohamed*