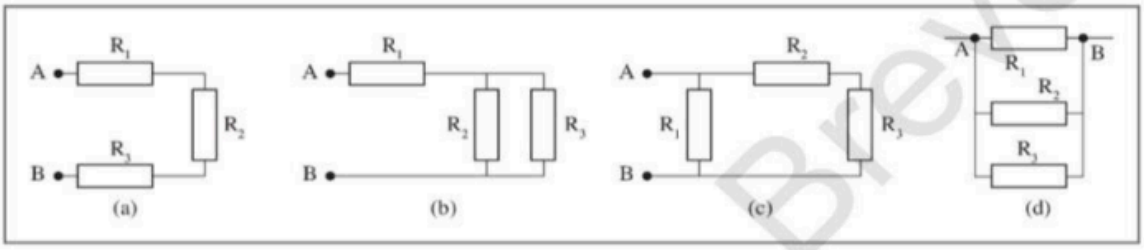
Name: Physics Sheet 4

Ahmad Jazzar

Grade 9 Unit 2 Electricity

Exercise 1: **Grouping of resistor**

Determine the equivalent resistance of the grouping of the following resistors seen between points A and B. Given: $R_1 = 50\ \Omega$, $R_2 = 20\ \Omega$ and $R_3 = 30\ \Omega$.



Exercise 2: **Voltage of the mains**

1) The adjacent graph represents the variations, as a function of time, of the voltage across the terminals of a generator.

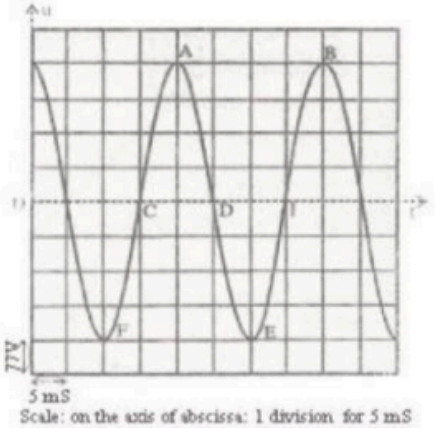
Take $\sqrt{2} = 1.4$

a) Is the voltage represented by the graph: direct (DC), triangular or alternating sinusoidal?

b) Specify a point on the graph that may be used to determine the maximum value U_m of the voltage.
Calculate U_m.

c) Name a couple of points on the graph that allows us to calculate the period T of that voltage.
Calculate T and deduce the frequency f.

d) A voltmeter, in the AC mode, connected across this generator, indicates a value U.
What does U represent relative to the voltage across the generator?
Calculate U.



Scale: on the axis of abscissa: 1 division for 5 mS
on the axis of ordinates: 1 division for 77V.

2) The voltage across a wall outlet in your house is identical to that represented by the graph. Why?

Exercise 3: Electric heater

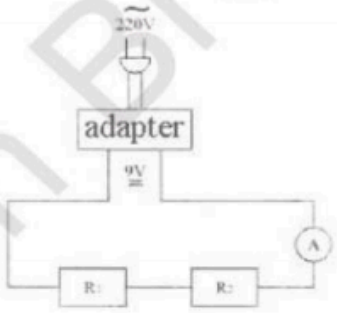
A house is equipped with a circuit breaker of 15A. The voltage of the mains across one of the outlets of this house is 220V.
We connect the heater across the outlet. The heater is formed of two resistors (D_1) and (D_2) of respective resistances $R_1 = 20\ \Omega$ and $R_2 = 30\ \Omega$.

1) The heater functions normally when (D_1) and (D_2) are connected in series.
- **a)** Draw a diagram representing (D_1) and (D_2) across the outlet.
- **b)** Calculate the resistance of the resistor equivalent to (D_1) and (D_2).
- **c)** Calculate the current carried by the circuit.
- **d)** Determine the energy consumed by the heater in two hours.

2) (D_1) and (D_2) are supposed to be connected in parallel.
- **a)** Calculate the main current.
- **b)** Explain why the circuit breaker will then open the circuit.

Exercise 4: Role of a fuse in an electric apparatus

The object of this exercise is to show evidence of the role of a fuse in an electric apparatus (an adapter). For this, we consider the circuit whose diagram is represented in the adjacent figure. It is formed of an ammeter (A) and two resistors (R_1) and (R_2) of respective resistances R_1=18Ω and R_2= 12Ω connected in series across the output of the adapter.

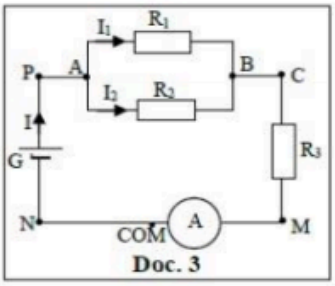


The adapter bears the following inscriptions for the input: **220V, 50Hz,** ~, and for the output: 9V ….. The output circuit of this adapter is protected by a fuse marked 400mA.

1- What does each of the three indications inscribed on the input of the adapter represent?
2- In order to feed the circuit with 9V DC, we must connect the input of the adapter across the mains. Justify
3- Calculate the resistance of the resistor equivalent to (R_1) and (R_2).
4- Determine the current carried by the circuit.
5- The resistor of resistance R_2 is short-circuited.
   - **a-** Determine the new value of the current.
   - **b-** The ammeter reads zero. Why? Explain then the role of the fuse.

Exercise 5: Determination of the resistance of a resistor

The circuit represented in document 3, consists of:
- a generator (G) maintaining across its terminals a constant voltage U_{PN} = 12 V;
- an ammeter (A) of negligible resistance;
- three resistors (R_1), (R_2) and (R_3) of respective resistances R_1 (unknown), $R_2 = 50\ \Omega$ and $R_3 = 20\ \Omega$.



Doc. 3

We denote by I the electric current in the main branch, by I_1 the electric current flowing through (R_1) and by I_2 the electric current flowing through (R_2).

The circuit is closed and the ammeter (A) reads 0.2 A.

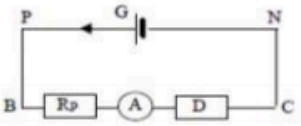
1. $U_{PA} = U_{BC} = 0$ V. Why?
2. $U_{MN} = 0$ V. Why?
3. Calculate, by applying Ohm's law, the value of the voltage U_{CM}.
4. Show, by applying the law of addition of voltages, that $U_{AB} = 8$ V.
5. Determine the electric current I_2 flowing in (R_2).
6. Deduce that the electric current flowing in (R_1) is $I_1 = 0.04$ A.
7. Calculate R_1.

Exercise 6: Measuring the resistance of a resistor

In order to measure the resistance of a resistor, three groups of students performed the following three experiments:

1- First experiment

The first group constructed the circuit of the adjacent figure.



The circuit consists of:

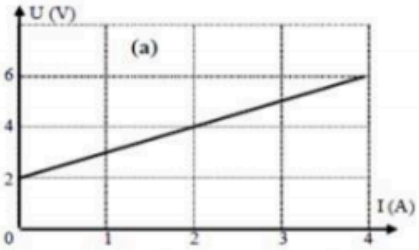
- A generator (G) maintaining between its poles P and N a constant voltage of value 12 V
- A resistor (D) of resistance R;
- An ammeter (A) of negligible resistance;
- A resistor R_p, used for protection, of resistance 14 Ω

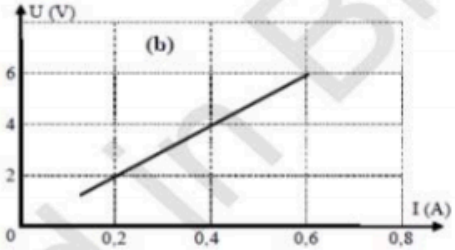
When the circuit is closed, the ammeter indicates 0.5 A.

a) Calculate the value of the voltage U_{BC}.
b) Calculate the resistance R_e equivalent to R_p and R.
c) Deduce the value of R.

2- Second experiment

The second group performed another experiment allowing to trace the characteristics of two different electrical components one of which is the component (D). They obtained the two graphs (a) and (b).





a) Graph (a) doesn't correspond to (D). Why?
b) Graph (b) corresponds to (D). Why?
c) Determine graphically the value of R.

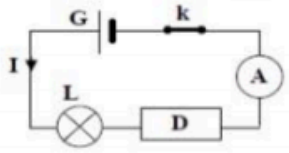
2- Third experiment

The third group measured directly the value of R using a certain instrument. Name this instrument.

Exercise 7: Voltage across a dry cell

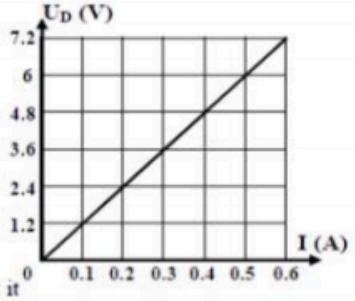
In order to determine the voltage across a dry cell G, we construct the circuit of the following figure. This circuit includes:

- the dry cell G;
- a lamp (L) with the indications (3 V; 1.5 W);
- an ohmic conductor (D);
- an ammeter (A) of negligible resistance;
- a switch (k);



1) a - Explain the meaning of each of the indications labeled on (L).
b - Prove, using these indications, that the intensity of the current flowing through (L), in normal functioning, is 0.5 A.

2) We close (K). (D) is chosen so that the ammeter (A) reads 0.5 A.
a- The same current of intensity **I** is then flowing through (D) and (L). Why? Determine the value of **I**.
b- The characteristic voltage-current (V-I) of the conductor (D) being given by the curve on the right, determine graphically the value of the voltage U_D across the terminals of (D).
c- Apply the law of addition of voltages to calculate the voltage U_G across the dry cell (G).



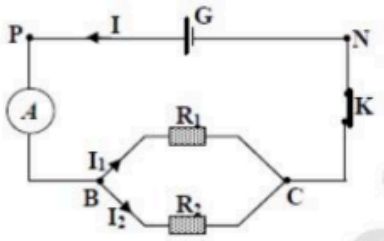
3) Name an instrument that allows the direct measurement of U_G. How must it be connected in the circuit?

Exercise 8: Study of an electric circuit

During a laboratory session, we construct the circuit represented in the adjacent figure.

- G is a generator that maintains across its terminals a constant voltage $U_{PN} = 12$ V.
- (A) is an ammeter of negligible resistance.
- (R_1) is a resistor of resistance $R_1 = 30\,\Omega$.
- (R_2) is a resistor of resistance R_2.
- (K) is a switch.

When we close (K), the ammeter (A) indicates 0.6 A.



1) Determination of the value of U_{BC}

a) The voltage across (A) is zero. Why?
b) The voltage across (K) is zero. Why?
c) The voltage U_{BC} is 12 V. Justify.

2) Determination of the value of R_2

a) Determine the value of the current I_1 through (R_1).
b) Deduce the value of the current I_2 through (R_2).
c) Show that the value of R_2 is $60\,\Omega$.

3) Equivalent resistance

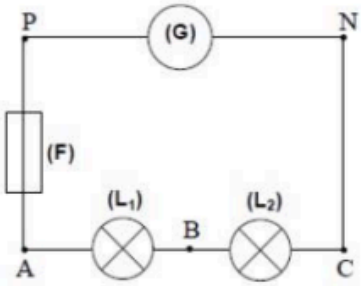
The two resistors (R_1) and (R_2) can be replaced by a single resistor (R) of resistance R, so that (A) indicates the same value I = 0.6 A.

a) Out of the following values ($90\,\Omega$; $50\,\Omega$; $20\,\Omega$), which one matches the value of R? Why?
b) An instrument allows a direct measurement of R. Name this instrument.

Exercise 9: Role of a fuse

In order to show evidence of the role of a fuse, we construct the circuit of the adjacent figure. This circuit includes in series :

- a generator (G) delivering across its terminals a constant voltage $U_{PN} = U = 24$ V.
- two identical lamps (L_1) and (L_2) considered as resistors, carrying the indications (12 V; 0.6 A).
- a fuse (F) of negligible resistance carrying the indication 0.65 A.



1) a) Give the significance of each of the indications carried by the lamps.
b) Determine the resistance of each of the two lamps

2) a) The voltage across (F) is zero. Why ?
b) Determine the values of the voltages U_1 and U_2 across the terminals of (L_1) and (L_2) respectively.
c) deduce that the lamps function normally.
d) What is then the value of the current I through the circuit?

3) The lamp (L_2) is short circuited
a) Give the value of the voltage U_2' across the terminals of (L_2). Justify.
b) Deduce the value of the voltage U_1' across the terminals of (L_1) and the value of the current I' through the circuit.
c) (L_1) may burn out. Why ?
d) In fact (L_1) does not burn out but it will be off. Explain.

Exercise 10: Study of an electric circuit

Consider:

- Two lamps (L_1) and (L_2) considered as resistors of resistances $R_1 = 60\ \Omega$ and $R_2 = 20\ \Omega$ respectively carrying the same inscription: 6 V.
- A generator (G) delivering across its terminals, P and N, a constant voltage $U_{PN} = 12$ V.

We intend to use (G) so as to make the two lamps function normally at the same time.

1. Assume that (L_1) and (L_2) are connected in series across the terminals of (G) as shown in figure 1.
   a) By applying the law of addition of voltages, show that the current through the circuit must be I = 0.15 A.
   b) Determine, in this case, the voltage across the terminals of each lamp.
   c) One of the two lamps has the risk to burn out while the other one gives faint light. Why?

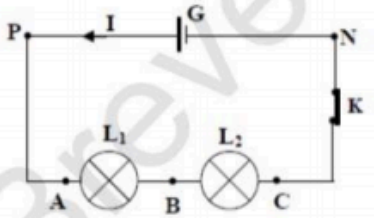


Fig. 1

2. For the lamps to function normally, we connect across (L_1) a resistor (D) of resistance R as shown in figure 2.
   a) Determine the value I_1 of the current through (L_1) and the value I_2 of the current through (L_2).
   b) Find, by applying the law of addition of currents, the value I_3 of the current through the resistor (D).
   c) Deduce the value of R.

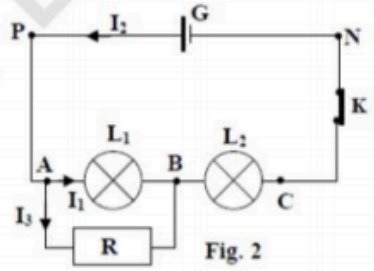
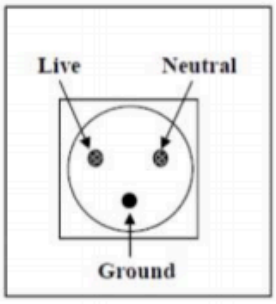


Fig. 2

Exercise 11: Wall outlet (Socket) and Normal functioning of a lamp

A) Document 1 represents a wall outlet of the mains for which the effective voltage is 220 V.



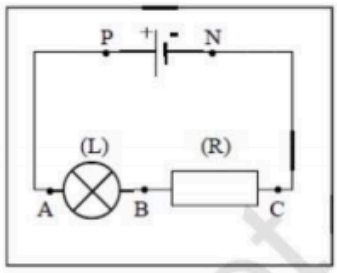
Document 1

Indicate, for each of the following statements, if it is true or false. Correct the false statements.

1. To distinguish between the live and the neutral terminals, we use a tester.
2. A voltmeter, adjusted on AC mode and connected across the ground and the neutral terminals, displays 220 V.
3. The voltage delivered by the wall outlet is alternating triangular.
4. The maximum value of the voltage of the mains is : $U_m = \frac{220}{\sqrt{2}}$ V.

B) Consider a lamp (L) carrying the inscriptions (9 V; 0.3 A) and a dry cell of constant voltage U_{PN}. (L) acts as a resistor (ohmic conductor) of resistance R_L.

In order to **function normally**, the lamp (L) is connected in series with a resistor (R) of resistance R (Document 2).



Document 2

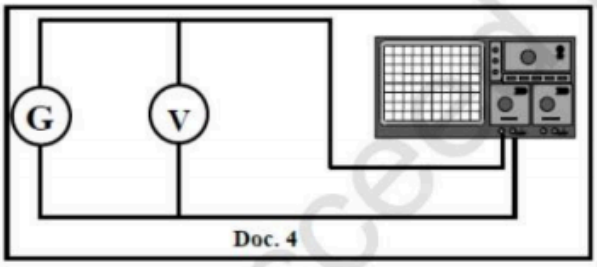
1. What does each of the inscriptions carried by (L) represent?
2. Determine R_L.
3. Show that the current passing through (R) is I = 0.3 A.
4. Using the law of addition of voltages, calculate the voltage U_{BC} across (R) knowing that U_{PN} = 12 V.
5. Deduce R.

Exercise 12: **Suitable voltage**

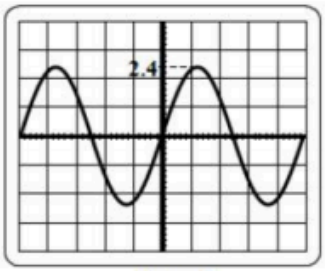
A voltmeter and an oscilloscope are connected across the terminals of a generator (G) delivering an alternating sinusoidal voltage u (document 4).
The document 5 represents the waveform of u.
In the absence of any voltage, the horizontal luminous line passes through the center of the screen.
The adjustments of the oscilloscope are:

- vertical sensitivity: S_v = 5 V/div;
- horizontal sensitivity: S_h = 10 ms/div.

Take $\sqrt{2} = 1.41$.



Doc. 4



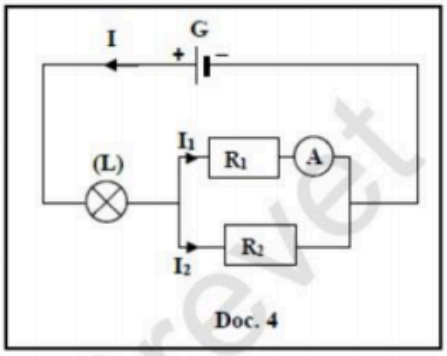
Doc. 5

1) The voltmeter measures a voltage U. What does U represent?
2) By referring to the document 5:
   - 2-1) Calculate the period T of u.
   - 2-2) Deduce the frequency f of u.
   - 2-3) Show that the maximum value of u is U_m = 12 V.
   - 2-4) Deduce U.
3) A lamp (L) marked 12 V is connected across (G). (L) does not glow normally. Justify.

Exercise 15:

A lamp (L), carrying the inscriptions (6 W; 12 V), is assumed as a resistor (ohmic conductor) of resistance r.

1. Show that the current carried by the lamp (L) while functioning normally is $I_o = 0.5$ A.
2. Calculate r.
3. The lamp (L) is placed in an electric circuit as shown in document 4.
   The resistors (R_1) and (R_2) have resistances
   $R_1 = 10\ \Omega$ and $R_2 = 20\ \Omega$ respectively.
   The ammeter (A), of negligible resistance, displays 0.1A.
   3.1. Calculate the value of the voltage U_1 across (R_1).
   3.2. Show that the current I_2 carried by (R_2) is 0.05 A.
   3.3. Deduce the current I through the lamp (L).
   3.4. Does (L) function normally in this circuit? Why?

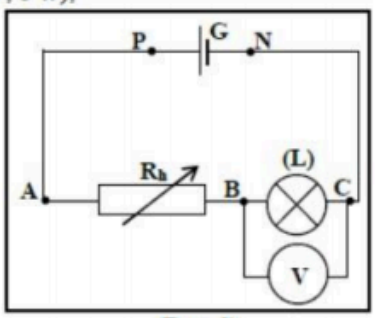


Doc. 4

Exercise 16:

The electric circuit of the document 3 consists of:
- a generator (G) of constant voltage $U_{PN} = 24$ V;
- a rheostat (R_h) of variable resistance;
- a lamp (L) acting as a resistor and carrying the indications (12 V; 6 W);
- a voltmeter (V) connected across the terminals of (L).

1) The resistance of the rheostat is adjusted such that the lamp functions normally.
   1.1) What does each of the indications carried by (L) represent?
   1.2) Show that the electric current flowing in (L) is $I_1 = 0.5$ A.
   1.3) Determine, by applying the law of addition of voltages, the voltage U_{AB} across the terminals of the rheostat.
   1.4) Show that the resistance of the rheostat is $R_1 = 24\ \Omega$.
2) The resistance of the rheostat is now adjusted at $R_2 = 0\ \Omega$.
   2.1) The voltmeter reads 24 V. Justify.
   2.2) The lamp burns out. Explain.



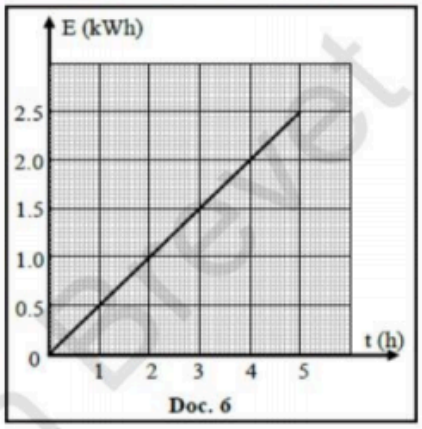
(Doc. 3)

Exercise 17:

An electric heater (H) carries two inscriptions. The first one is 220 V and the other is expressed in watt but its numerical value is erased. (H) functions normally when it is connected to the wall outlet of a domestic installation.

The document 6 represents the variations of the electric energy E consumed by (H) as a function of time t.

1) The electric energy consumed by this electric heater is given by the relation: E = a×t, where "a" is a physical quantity that characterizes (H).
   - 1-1) Show that the shape of the curve of the document 6 is in agreement with the given relation.
   - 1-2) By referring to the graph of document 6, give the value of E during 5 hours of functioning.
   - 1-3) Deduce the value and the unit of "a".
   - 1-4) What does "a" represent?
   - 1-5) Give then the numerical value of the erased inscription.
2) (H) is considered as a resistor (ohmic conductor) of resistance R. Determine R.

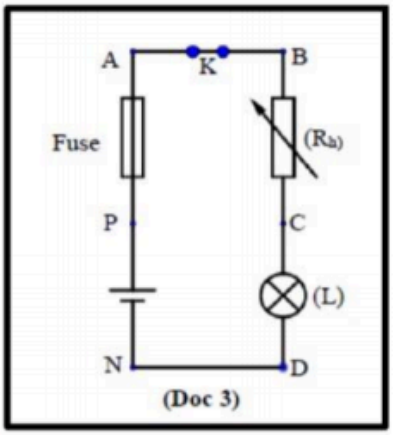


Doc. 6

Exercise 18:

The adjacent document (Doc 3) represents a circuit formed of:

- A battery supplying, across its terminals, a constant voltage U_{PN} = 12 V;
- A fuse that can support a maximum current of 0.6 A;
- A closed switch K;
- A rheostat (R_h) of adjustable resistance;
- A lamp (L) acting as a resistor and carrying the label (9V; 4.5 W).



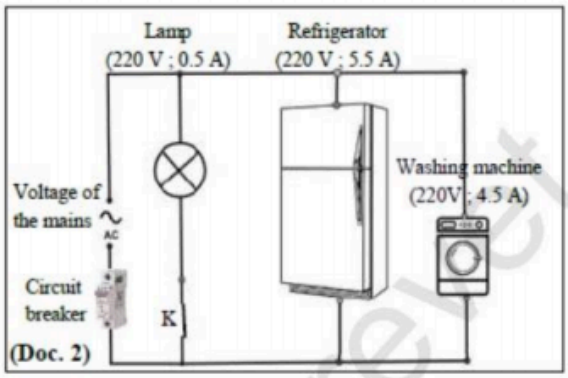
(Doc 3)

1) The lamp functions normally.
   - 1-1) Indicate the significance of the label (9 V; 4.5 W).
   - 1-2) Deduce the value of the current I carried by the lamp (L).
   - 1-3) Calculate the resistance R of the lamp (L).
2) Starting from a certain value, we decrease the resistance of the rheostat. The brightness of the lamp increases gradually. Calculate, just before the fuse melts:
   - 2-1) The voltage U_{CD} across the lamp (L);
   - 2-2) The voltage U_{BC} across the rheostat knowing that the voltage across the fuse is nil; U_{PA} = 0.

Exercise 19:

The electric installation of a kitchen, represented in (Doc. 2), is fed by an alternating sinusoidal voltage, of effective value U = 220 V.
This installation contains the following electric devices:

- A lamp;
- A refrigerator;
- A washing machine.

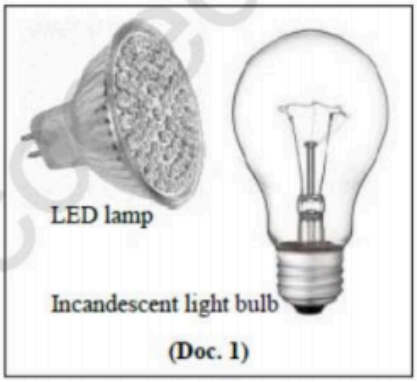


(Doc. 2)

1) All the electric devices function normally. Justify.
2) All the devices are functioning normally at the same time. Specify, among the circuit breakers marked 10 A, 15 A and 30 A, the one that is the most convenient to protect this installation.
3) At the end of 24 hours, the refrigerator, of power 990 W, consumes an electric energy of 9.9 kWh. Specify whether the compressor of this refrigerator is working permanently.

Exercise 20:

The aim of this exercise is to show evidence of the importance of the replacement of an incandescent light bulb by a LED lamp, both producing the same luminosity (Doc. 1).



(Doc. 1)

Consider the two lamps (A) and (B). (A) is an incandescent light bulb carrying the indications (220 V, 100 W) and (B) is a LED lamp carrying the indications (220 V, 25 W). The two lamps are considered as resistors functioning for the same duration of 5 hours per day.

1) Justify that the two lamps function normally when they are connected across the mains in Lebanon.
2) Calculate, in kWh, the electric energy consumed by the lamp (A) for 5 hours.
3) Show that the monthly consumption of the lamp (A) is 15 kWh.
4) The average cost of each kWh is 200 LP. Deduce the monthly cost due to the use of the lamp (A).
5) The monthly cost of the electric energy consumed by lamp (B) for the same duration is 750 LP. Conclude while comparing the monthly cost of each lamp.