الاسم:	مسابقة في مادة الفيزياء
الرقم:	المدة: ساعة واحدة

This exam is formed of three obligatory exercises in two pages
## Non programmable calculators are allowed

First exercise (7 points)   Principle of reversibility of light

The aim of this exercise is to verify the principle of reversibility of light. The principle states that the path of light is independent of its direction of propagation.

Consider a semi-cylindrical glass of center O. ON and OP represent the normal at N and at P respectively on the surface of separation of the system (air-glass) as shown in figure.

A luminous ray SM passes from air into glass at the point of incidence M.

The limiting (critical) angle of refraction of the system (air – glass) is $i\ell = 42^{o}$.
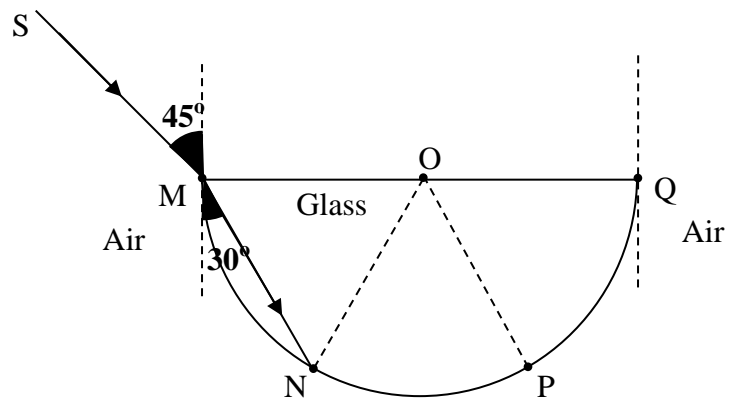
1) Refer to the adjacent figure:
   a) give the values of the angle of incidence and the angle of refraction at M.
   b) deduce that glass is more refractive than air.
2) At point N,
   a) show that the value of the angle of incidence is 60°.
   b) the ray MN does not leave the glass. Justify.
   c) name the phenomenon that the ray MN undergoes.
3) Now the ray reaches point P.
   a) Redraw the adjacent figure and complete, without justification, the path of ray till it meets Q.
   b) Knowing that the angle of incidence at Q is 30°. choose, Among the angles 25°, 30° and 45°,the corresponding angle of refraction of the emergent ray. Justify your answer by referring to part (1-b).
4) The principle of reversibility is verified. Explain.

Second exercise (7 points)   Electric circuit

An electric circuit is connected up as shown in the adjacent figure. The battery supplies a constant voltage U_{PN} = 12 V. The two resistors R_1 and R_2 have resistances 10 Ω and 15 Ω respectively. Lamp (L) acts as a resistor of resistance R_L = 10 Ω and bears the inscription 4.5 V.

1) The voltage across R_2 and L is the same. Justify.
2) Show that the equivalent resistance of R_2 and L is $R' = 6$ Ω.
3) Deduce the equivalent resistance R_e between A and B of the circuit.
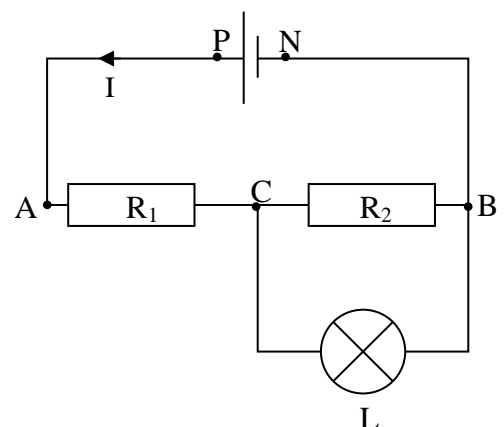
4) By applying Ohm's law, calculate the main current I in the electric circuit.
5) Determine U_{CB}.
6) The lamp (L) functions normally. Explain.
7) We replace R_1 by a connecting wire of negligible resistance:
   a) give the value of U_{AC}.
   b) determine $U_{CB.}$
   c) show that the lamp may burn out.

Third exercise (6 points)   Hooke's law

A spring balance is suspended vertically with its upper end fixed to a support. Its lower end carries a solid (S).
The spring balance undergoes compression as shown in figure 1.
The curve in figure 2 shows the variation of the magnitude of the tension T exerted by the spring on (S) as a function of the compression x of the spring.
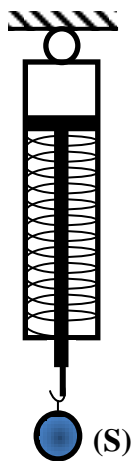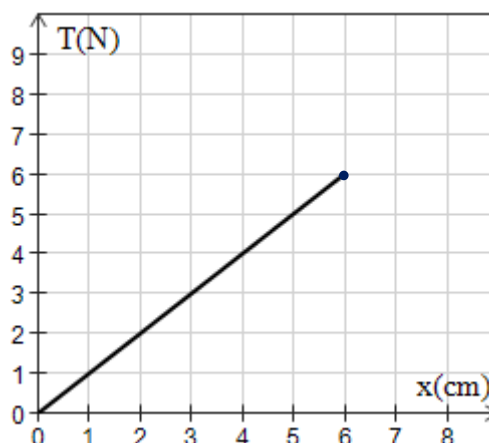Take g = 10 N/kg.

Fig. 1   Fig. 2

1) Refer to the graph and complete the table below:

T(N)	1		5
x(cm)		3	

2) Hooke's law is given by the relation:
        T = k.x   where k is a physical quantity that characterizes the spring.
   Give the name of k.
3) Calculate its value in SI unit.
4) (S) is submitted to two forces. $\vec{T}$ is one of them. Name the other force.
5) (S) is at equilibrium. The maximum compression of the spring is x = 6 cm.
   a) Write the condition of equilibrium.
   b) Give, graphically, the magnitude of the corresponding tension.
   c) Deduce the maximum magnitude of the weight that can be measured by the spring balance.
   d) Calculate the maximum value of the mass that can be measured.
6) A greengrocer cannot use this spring balance to measure 1 kg of potato bag. Justify.

First exercise (7 points)

Part of the Q.	Answer	Mark
1.a)	i = 45° , r = 30°.	0.25+0.25
1.b)	i = 45^0> r = 30^0 or the refracted ray deviates towards the normal.	0.5
2.a)	In the triangle OMN: OM = ON,(2 radii in the same semi-circle), $O\widehat{M}N$ = 90° – 30° = 60°, the triangle is equilateral so $O\widehat{N}M$ = i = 60°.	0.5 0.5 0.5
2.b)	Since i = 60° > iℓ = 45°.	1
2.c)	Total internal reflection.	0.5
3.a)	Drawing.	1
3.b)	r = 45°> i = 30^0, the ray deviates away from the normal (from glass to air).	1
4.	For i = 45°, r = 30° (from air to glass), for i = 30°, r = 45° (from glass to air).	1

Second exercise (7 points)

Part of the Q.	Answer	Mark
1)	They are connected in parallel (law of uniqueness of voltage)	0.5
2)	$\frac{1}{R'} = \frac{1}{R_2}+\frac{1}{R_L}$ then R' = 6 Ω or $R' = \frac{R_L \cdot R_2}{R_L+R_2}$ = 6 Ω.	1
3)	R_e = R_1 + R' = 6 + 10 = 16 Ω.	1
4)	U_{AB} = R_e.I , 12 = 16×I ⇒ I = 0.75 A.	1
5)	U_{CB} = R'.I = 6×0.75 = 4.5 V.	1
6)	The lamp functions normally since U_{CB} = U_{rated} = 4.5V	0.5
7- a)	U_{AC} = 0 V	0.5
7- b)	U_{PN} = U_{PA} + U_{AC} +U_{CB} +U_{BN} 12 = 0 + 0 + U_{CB} + 0 ⇒ U_{CB} = 12 V	1
7- c)	U_{CB} = 12 V > U_{rated} = 4.5 V	0.5

Third exercise (6 points)

Part of the Q.	Answer				Mark
1)	**T(N)**	1	3	5	0.75
	x(cm)	1	3	5	
2)	Stiffness constant (spring constant)				0.5
3)	k = $\frac{T}{x}$ = $\frac{1}{0.01}$ = 100 N/m.				1
4)	Weight of (S).				0.25
5- a)	$\vec{T} + \vec{W} = \vec{0}$.				0.5
5- b)	At x = 6 cm, T = 6 N (from graph).				0.5
5- c)	T = W = 6 N (at equilibrium).				0.5
5- d)	W = m.g, m = $\frac{W}{g}$ = 0.6 kg.				1
6)	The mass of potato bag is 1 kg > m_{max} = 0.6 kg.				1