وزارة التّربية والتّعليم العالي
المديريّة العامّة للتّربية
دائرة الامتحانات الرسميّة

امتحانات الشهادة الثانويّة العامّـة
فرع العلوم العامّة

دورة العام 2025 العادية
السبت 12 تموز 2025

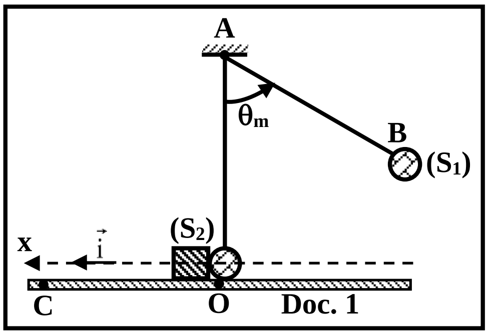
مسابقة في مادّة الفيزياء — الاسم:
المدّة: 3 ساعات — الرّقم:

This exam is formed of four obligatory exercises in four pages.
The use of non-programmable calculator is recommended.

Exercise 1 (7.5 pts) — Energy and collision

Consider a simple pendulum and a block (S_2):

- The simple pendulum is formed of a sphere (S_1), taken as a particle of mass $m_1 = 200$ g and suspended to the lower end B of a light inextensible string of length $\ell = 1.6$ m. The upper end of the string is fixed, at A, to a support.
- The block (S_2) is considered as a particle of mass $m_2 > m_1$.



The pendulum can swing in a vertical plane around a horizontal axis (Δ) passing through A. At an instant t, the position of the pendulum is given by the angle θ between the vertical through point A and the string AB.

While keeping the string taut, the pendulum is displaced by an angle θ_m from its equilibrium position $(\theta = 0)$, and then released without initial velocity at $t_0 = 0$. When (S_1) reaches point O, it enters into collision with (S_2).

The aim of this exercise is to study the motion of (S_2) after this collision.

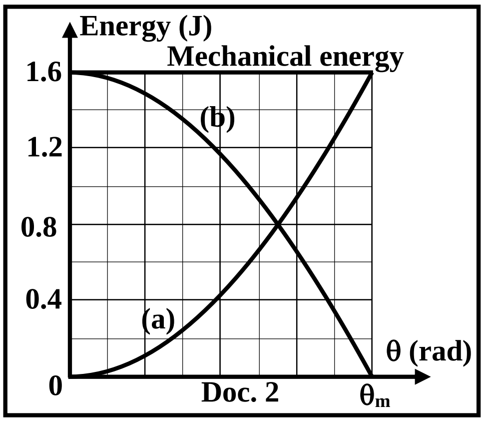
The x-axis is a horizontal axis with unit vector $\vec{i}$ passing through the lower position of (S_1) (Doc. 1).

Take:

- The horizontal plane containing the x-axis as the reference level for gravitational potential energy;
- $g = 10$ m/s^2.

1) Motion of the simple pendulum

The curves of document 2 represent the gravitational potential energy, kinetic energy and mechanical energy of the system (Pendulum, Earth) as a function of θ during the descending motion of the pendulum between $\theta = \theta_m$ and $\theta = 0$.



Using document 2:

1.1) Justify that air resistance and friction at the axis (Δ) are negligible.

1.2) Show that curve (a) corresponds to the gravitational potential energy and curve (b) to the kinetic energy.

1.3) Determine the value of θ_m.

1.4) Show that the speed of (S_1) when it reaches O, just before the collision, is $V_1 = 4$ m/s.

2) Collision between (S_1) and (S_2)

(S_1) reaches point O with a velocity $\vec{V_1} = 4\,\vec{i}$ (m/s). (S_1) undergoes a head-on elastic collision with (S_2), initially at rest, on a horizontal surface (Doc. 1).

Just after the collision, the velocity of (S_2) is $\vec{V_2'} = V_2'\,\vec{i}$ and (S_1) rebounds with a velocity $\vec{V_1'} = -V_2'\,\vec{i}$ (Doc. 1).

2.1) Determine the algebraic value V_1' of the velocity $\vec{V_1'}$.

2.2) Deduce that $m_2 = 3\,m_1$.

3) Motion of (S_2) after the collision

After the collision, (S_2) moves along the x-axis and stops at point C due to the existence of friction force $\vec{f} = -f\,\vec{i}$ of constant magnitude f.

Take the instant $t_0 = 0$ as the new initial time just after collision. The following table shows the algebraic value V of the velocity of (S_2) at different instants:

t (s)	$t_0 = 0$	$t_1 = 1$	$t_2 = 2$	$t_3 = 3$	$t_4 = 4$
V (m/s)	2	1.5	1	0.5	0

3.1) Calculate the algebraic values P_0, P_1, P_2, P_3 and P_4 of the linear momentum $\vec{P}$ of (S_2) at the instants t_0, t_1, t_2, t_3 and t_4 respectively.

3.2) Plot, on the graph paper, the curve of the linear momentum P as a function of time.

Take the scale:

- on the abscissa axis:1 cm ↔ 1 s;
- on the ordinate axis:1 cm ↔ 0.2 kg.m/s.

3.3) Show that the equation corresponding to the curve can be written in the form: $P = at + b$ where a and b are constants to be determined.

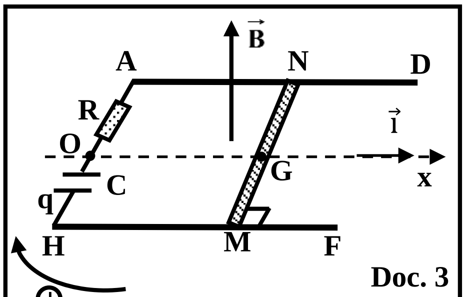
3.4) Applying Newton's second law on (S_2), determine f.

3.5) Determine the distance OC.

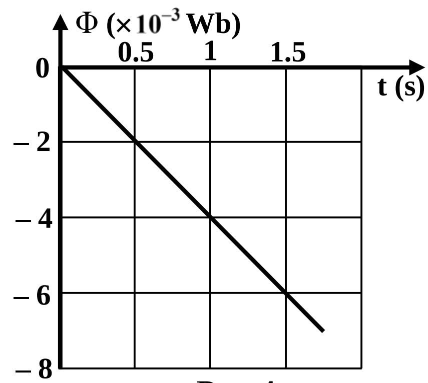
Exercise 2 (7 pts) Electromagnetic induction and charging a capacitor

The aim of this exercise is to study the charging of a capacitor in a circuit carrying an induced current.
For this aim, consider:

- Two parallel conducting rails, AD and HF, separated by a distance $\ell = 20$ cm, which are placed in a horizontal plane.
- A rigid conducting rod MN, of length ℓ and perpendicular to the rails, moves without friction on the rails. The center of mass G of the rod moves along a horizontal x-axis of unit vector $\vec{i}$.
  The ends A and H of the rails are connected to a resistor of resistance $R = 10\ \Omega$ and a capacitor, initially uncharged, of capacitance C.



Doc. 3



Doc. 4

The rod and the two rails are assumed to have negligible resistance.
The circuit formed by the two rails and the rod is placed in a vertical uniform magnetic field $\vec{B}$ perpendicular to the plane of the rails and of magnitude B = 0.04 T (Doc. 3).
At the instant $t_0 = 0$, G coincides with the origin O of the x-axis, and the rod moves at a constant velocity $\vec{V} = V\ \vec{i}$ (m/s), along the positive x-direction.
At an instant t, the abscissa of G is $x = \overline{OG} = V \times t$.

1) During the motion of the rod, the magnetic flux crossing the closed circuit ANMH varies with time.

1.1) Indicate the cause of change of this magnetic flux.

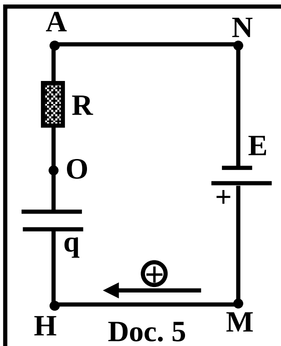
1.2) Determine, taking into consideration the positive direction shown in document 3, the expression of the magnetic flux ϕ crossing this circuit in terms of B, ℓ, V and t.

1.3) Document 4 represents ϕ as a function of time. The shape of this curve is in agreement with the expression of ϕ in part (1.2). Justify.

1.4) Deduce the value of V.

1.5) Deduce the value of the electromotive force "e" induced in the rod.

2) During its motion, the rod is equivalent to an ideal battery of electromotive force $E = e = u_{MN} = 4$ mV.
At an instant t, the plate H of the capacitor carries a charge q and an induced current i flows through the circuit ANMH (Doc. 5).



Doc. 5

2.1) Show that the differential equation that governs the variation of the voltage $u_{HO} = u_C$ across the capacitor is: $E = RC\dfrac{du_C}{dt} + u_C$.

2.2) The solution of this differential equation is of the form: $u_C = a - a\,e^{\frac{-t}{\tau}}$, where a and τ are constants. Determine the expressions of a and τ in terms of E, R and C.

2.3) Show that the expression of the voltage $u_{OA} = u_R$ across the resistor, is $u_R = 4\times10^{-3}\,e^{\frac{-t}{\tau}}$ (SI).

2.4) Knowing that $u_C = u_R$ at t = 0.7 ms, determine the value of C.

3) An electromagnetic force (Laplace's force) $\vec{F}$ is acting on the moving rod MN during an interval of time $[t_0 ; t_1]$.

3.1) Indicate the direction of this force.

3.2) Knowing that the magnitude of $\vec{F}$ is $F = i\ell B$, determine, in terms of t, the expression of F.

3.3) Deduce the instant t_1, when Laplace's force becomes practically zero.

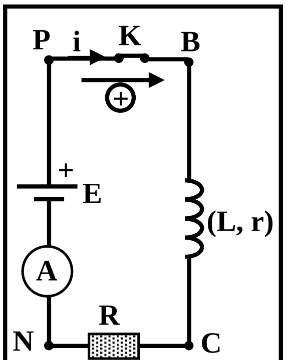
Exercise 3 (6.5 pts) Self-induction

The aim of this exercise is to determine the inductance L and the resistance r of a coil.

For this aim, we set-up the series circuit of document 6 that includes:

- an ideal battery of electromotive force E = 10 V;
- a resistor of resistance R = 90 Ω;
- a coil of inductance L and resistance r;
- an ammeter (A) of negligible resistance;
- a switch K.

At $t_0 = 0$, we close the switch K. At an instant t, the circuit carries a current i.



Doc. 6

1) When switch K is closed, a self-induction phenomenon occurs in the circuit. Define this phenomenon.

2) Establish the first order differential equation that describes the variation of the current i as a function of time.

3) Verify that $i = I_m(1 - e^{\frac{-t}{\tau}})$ where $\tau = \frac{L}{R+r}$ and $I_m = \frac{E}{R+r}$, is a solution of the previous differential equation.

4) Once steady state is established in the circuit, the ammeter displays 100 mA. Deduce the value of r.

5) Show that : $\ell n\left(1 - \frac{i}{I_m}\right) = -\frac{1}{\tau}\times t$.

6) The table below gives different values of i measured at different times t.

t (ms)	0	0.2	0.4	0.8	1.0	1.4	1.8	2.0
i (mA)	0	18.2	33.0	55.1	63.3	75.4	83.5	86.5
$\ell n\left(1-\frac{i}{I_m}\right)$								

6.1) Copy and complete this table.

6.2) Trace, on the graph paper, the curve that represents $\ell n\left(1-\frac{i}{I_m}\right)$ as a function of time.

Take the scale:

- on the abscissa axis: 1 cm ↔ 0.2 ms;
- on the ordinate axis: 1 cm ↔ 0.2.

6.3) Referring to the obtained curve, show that: $\ell n\left(1-\frac{i}{I_m}\right) = -1000\,t$ (S.I).

7) Deduce the values of τ and L.

Exercise 4 (6.5 pts) **Photoelectric effect**

For a pure metal with a work function W_0, photoelectric emission may occur under certain condition. The emitted photoelectrons possess a kinetic energy KE. The electrons thus ejected form an electric current I. The aim of this exercise is to determine I by illuminating a plate coated with sodium.

Given:

- speed of light in vacuum $c = 3\times10^{8}$ m/s;
- elementary charge $e = 1.6\times10^{-19}$ C ;
- 1 eV = 1.6×10^{-19} J;
- Visible spectrum: 400 nm < $\lambda_{visible}$ < 800 nm.

1) Choose the statement that correctly describes « photoelectric emission ».
Statement 1: It is the emission of photons from a metal when exposed to a beam of electrons.
Statement 2: It is the emission of electrons from a metal when exposed to electromagnetic radiation of suitable frequency.
Statement 3: It is the emission of electrons from a metal when exposed to a beam of electrons.

2) Based on Einstein's equation for the photoelectric effect, show that the maximum kinetic energy of the extracted electron as a function of the frequency ν of the incident radiation, can be written as: $KE_{max} = a\,\nu + b$; where a and b are constants to be determined in terms of W_0 and Planck's constant h.

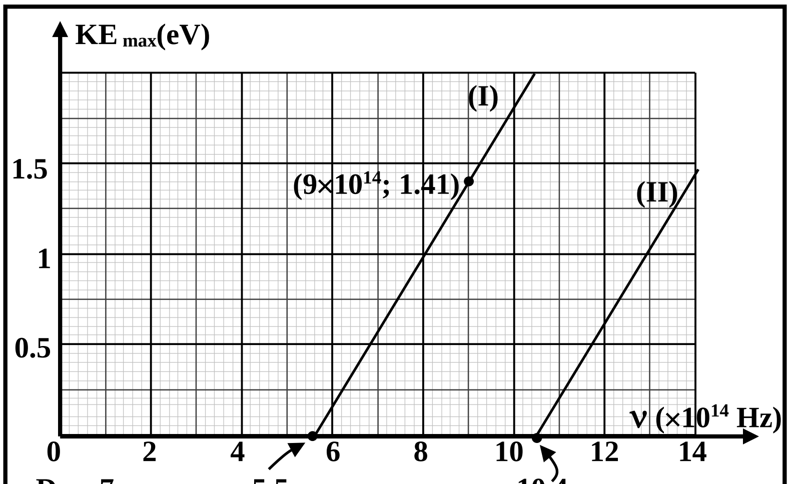
3) The curves (I) and (II) in document 7 show KE_{max} as a function of « ν » for two different metals whose threshold frequencies are denoted by « ν_{0_1} » and « ν_{0_2} ».

3.1) The curves obtained for each metal is in agreement with the relation obtained in part (2). Justify.

3.2) The two straight lines of document 7 are parallel. Justify this statement, using the expression of KE_{max} in part (2).

3.3) Using curve (I), determine h in SI.

3.4) Using document 7, determine the values of the threshold wavelength « λ_{0_1} » and « λ_{0_2} » corresponding to curves (I) and (II) respectively.



Doc. 7

4) The two studied metals are sodium and zinc. Knowing that zinc wouldn't produce photoelectric emission when exposed to a visible radiation, indicate which one of the two curves (I) and (II) corresponds to zinc. Justify.

5) A sodium-coated plate receives a light of power $P = 2\times10^{-3}$ W from a monochromatic source of wavelength $\lambda = 400$ nm in vacuum.

5.1) Determine the number N of photons received by the plate in one second.

5.2) Deduce the number n of emitted electrons per second, knowing that for this radiation the quantum efficiency of the plate is $r = \dfrac{n}{N} = 0.02$.

5.3) The emitted electrons form an electric current I. Calculate I using $I = n\times e$.

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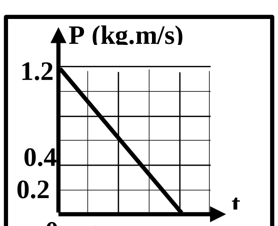
دورة العام 2025 العادية

مسابقة الفيزياء
أسس التصحيح - إنكليزي

Exercise 1 (7.5 points) — Collision

Part	Answer	grade
1.1	Air resistance and friction at the axis are negligible because: ME = constant = 1.6 J	**0.25**
1.2	Curve (a) : Gravitational potential energy. First method: during the motion of the pendulum between $\theta = \theta_m$ and $\theta = 0$, it approaches the reference level of GPE therefore GPE max for $\theta = \theta_m$ and decreases to zero for $\theta = 0$. Second method: At $t_0 = 0$, we have $\theta = \theta_m$, the height of the pendulum is maximum, then GPE = ME. Curve (b): kinetic energy. First method: during the motion of the pendulum between $\theta = \theta_m$ and $\theta = 0$, the speed of the pendulum increases; therefore, KE increases, for $\theta = \theta_m$, kE= 0 and increases to reach its maximum value KE = ME for $\theta = 0$. second method: At $t_0 = 0$ we have $\theta = \theta_m$ and the speed of the pendulum is zero, then KE is zero.	**0.5** **0.5**
1.3	At $t_0 = 0$ we have $\theta = \theta_m$: GPE = mgh and $h = \ell(1 - \cos\theta_m)$ $1.6 = mg\,\ell(1 - \cos\theta_m) = 0.1\times10\times0.4\times(1 - \cos\theta_m)$, then : $\cos\theta_m = 0.5$, then $\mathbf{\theta_m = 60^o = \pi/3}$	**0.5**
1.4	ME = constant = 1.6 J When the pendulum reaches its equilibrium position, and just before the collision $\theta = 0$ and $ME = KE = \frac{1}{2} m_1 V_1^2$; therefore, $1.6 = \frac{1}{2} \times 0.2 \times V_1^2$, then $V_1 = 4$ m/s	**0.5**
2.1	$\vec{P}_{\textbf{before collision}} = \vec{P}_{\textbf{after collision}}$ $m_1 \vec{V}_1 = m_1 \vec{V'_1} + m_2 \vec{V'_2}$; Collinear collision: $m_1 V_1 = m_1 V'_1 + m_2 V'_2$ Then: $m_1(V_1 - V'_1) = m_2 V'_2$ …. eq (1) **The collision is elastic, so there is conservation of the kinetic energy of the system [(S₁) , (S₂)]** $KE_{before} = KE_{after}$; $\frac{1}{2} m_1 V_1^2 = \frac{1}{2} m_1 V_1'^2 + \frac{1}{2} m_2 V_2'^2$; $m_1(V_1^2 - V_1'^2) = m_2 V_2'^2$ … eq (2) $\frac{eq.(2)}{eq.(1)}$: $V_1 + V'_1 = V'_2$ … eq (3) ; Since (S₁) rebounds with a velocity $\vec{V'_1} = -V'_2\,\vec{i}$ given $V'_1 = -V'_2$; Therefore, $V'_1 = -\frac{V_1}{2} = -$ **2 m/s**	**1.25**
2.2	We replace $V_1 = 4$ m/s ; $V'_1 = -2$ m/s and $V'_2 = 2$ m/s in equation 1: $m_1(V_1 - V'_1) = m_2 V'_2$; $m_1(4 + 2) = m_2(2)$; $6 m_1 = 2m_2$ then $m_2 = 3 m_1$	**0.5**
3.1	$P_0 = m_2V_0 = 0.6 \times 2 =$ **1.2 kg.m/s** ; $P_1 = 0.6 \times 1.5 =$ **0.9 kg.m/s** $P_2 = 0.6 \times 1 =$ **0.6 kg.m/s** ; $P_3 = 0.6 \times 0.5 =$ **0.3 kg.m/s** ; $P_4 = 0.6 \times 0 =$ **0 kg.m/s**	**0.5**
3.2		**0.5**

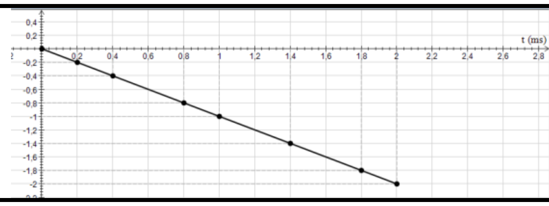
3.3	The shape is a straight line having a negative slope, its equation is of the form: P = at + b A t = 0: P = 1.2 , then b = 1.2 kg.m/s A t = 4 s : P = 0, then 0 = 4 a + 1.2 , we obtain : a = – 0.3 kg.m/s^2, Therefore : **P = – 0.3 t + 1.2** with P in kg.m/s and t in second.	**0.75**
3.4	We apply Newton's second law on (S): $\Sigma \overrightarrow{F_{ext}} = \frac{d\vec{P}}{dt}$, then $m_2\vec{g} + \vec{N} + \vec{f} = \frac{d\vec{P}}{dt}$; But $m_2\vec{g} + \vec{N} = \vec{0}$, and $\frac{d\vec{P}}{dt} = -0.3\ \vec{i}$ Then: $-0.3\ \vec{i} = -f\ \vec{i}$; therefore, **f = 0.3 N**	**1**
3.5	The variation in the mechanical energy is equal to the work done by the friction force. $\Delta ME = W_{\vec{f}}$, then $\Delta ME = ME_C - ME_o = (KE_C + GPE_C) - (KE_o + GPE_o) = (KE_C) - (KE_o)$ $\Delta ME = \frac{1}{2} m_2 \left(v_C^2 - v_0^2\right) = 0.5 \times 0.6\ (0 - 2^2) = $ **– 1.2 J** $\Delta ME = W_{\vec{f}}$ – 1.2 = – 0.3 × OC ; therefore, **OC = 4 m**	**0.75**

Exercise 2 (7 pts) Electromagnetic induction and charging a capacitor		
Part	**Answer**	**grade**
1.1	The variation in magnetic flux passing through the closed ANMH surface is due to the **increase in the area** crossed by the magnetic field lines.	**0.25**
1.2	$\phi = B.S.\cos(\vec{B}, \vec{n}) = B.(\ell x).\cos(\pi) = $ **- BℓVt**	**0.5**
1.3	The curve is a straight line passing through the origin with a negative slope, so its equation is of the form : ϕ = K × t (K is negative constant) Therefore, the curve is an agreement with the relation ϕ = -BℓVt (BℓV = constant positive)	**0.5**
1.4	From document : slope = $\frac{-6-0}{(1.5-0)\times 10^{-3}} = -4\times 10^3$ Wb/s Form the expression of flux in question 2: slope = – BℓV therefore : V = $\frac{-4\times 10^3}{-0.04\times 0.2} = 0.5$ m/s	**0.5** **0.5**
1.5	$e = -\frac{d\phi}{dt} = BlV = $ **4×10^{-3} V = 4 mV**	**0.5**
2.1	Law of addition of voltages: $u_{MN} = u_{MH} + u_{HO} + u_{OA} + u_{AN}$ $E = u_C + R\,i$, but $i = \frac{dq}{dt}$ and $q = C\,u_C$ then $i = C\frac{du_C}{dt}$; therefore : $E = RC\frac{du_C}{dt} + u_C$	**0.25** **0.5**
2.2	$u_C = a - a\,e^{\frac{-t}{\tau}}$; $\frac{du_C}{dt} = \frac{a}{\tau} e^{\frac{-t}{\tau}}$; we replace u_C and $\frac{du_C}{dt}$ in the differential equation: $E = RC\frac{a}{\tau} e^{\frac{-t}{\tau}} + a - a\,e^{\frac{-t}{\tau}}$; $a\ e^{\frac{-t}{\tau}} [\frac{RC}{\tau} - 1] + a = E$ This equality is verified at any time t, by identification: $a\ e^{\frac{-t}{\tau}} \neq 0$ then **a = E = 4×10^{-3} V** and $-\frac{RC}{\tau} + 1 = 0$ so **τ = R C** $u_C = 4\times 10^{-3}\ (1 - e^{\frac{-t}{\tau}})$ with τ = RC	**0.5** **0.5**

2.3	$i = C\,\frac{du_C}{dt} = C \times 4\times10^{-3}\,\frac{1}{\tau}\,e^{\frac{-t}{\tau}} = \frac{4\times10^{-3}}{R}\,e^{\frac{-t}{\tau}} = 0.4\times10^{-3}\,e^{\frac{-t}{\tau}}$ $u_R = Ri = 10\times0.4\times10^{-3}\,e^{\frac{-t}{\tau}} = 4\times10^{-3}\,e^{\frac{-t}{\tau}}$	**0.25** **0.5**
2.4	$u_c = u_R$; $4\times10^{-3}\,(1 - e^{\frac{-t}{\tau}}) = 4\times10^{-3}\,e^{\frac{-t}{\tau}}$; $2\,e^{\frac{-t}{\tau}} = 1$ $\frac{-t}{\tau} = \ln\left(\frac{1}{2}\right)$; $C = \frac{t}{R\times\ln2} = \mathbf{1.009\times10^{-4}\ F \approx 101\ \mu F}$	**0.75**
3.1	Direction : to the left	**0.25**
3.2	$F = i\,B\,\ell = 0.4\times10^{-3}\,e^{\frac{-t}{\tau}} \times 0.04\times0.2 = 3.2\times10^{-6}\,e^{\frac{-t}{1\times10^{-3}}}$ (F in N et t in s)	**0.5**
3.3	For $t_1 = 5\tau = \mathbf{5\times10^{-3}\ s}$; $F = 2.15\times10^{-8}$ N ≈ 0 N	**0.25**

Exercise 3 (6.5 pts)	**Self-induction**	
Part	**Answer**	**grade**
1	Self-induction is the appearance of an e.m.f in a circuit carrying a variable current.	**0.5**
2	Law of addition of voltages : $u_{PN} = u_{PB} + u_{BC} + u_{CN}$; $E = ri + L\frac{di}{dt} + Ri = (R+r)i + L\frac{di}{dt}$	**0.5**
3	$i = I_m\,(1 - e^{-\frac{t}{\tau}})$; $\frac{di}{dt} = \frac{I_m}{\tau}\,e^{-\frac{t}{\tau}}$ We replace i and $\frac{di}{dt}$ in the differential equation $E = (R + r)\,I_m\,(1 - e^{-\frac{t}{\tau}}) + L\,\frac{I_m}{\tau}\,e^{-\frac{t}{\tau}}$; We replace constants $\tau = \frac{L}{R+r}$ and $I_m = \frac{E}{R+r}$ We obtain : $E = (R+r)\,\frac{E}{R+r}\,(1 - e^{-\frac{t}{\tau}}) + L\,\frac{E(R+r)}{(R+r)L}\,e^{-\frac{t}{\tau}}$ $E = E - E\,e^{-\frac{t}{\tau}} + E\,e^{-\frac{t}{\tau}}$ We obtain: E = E The solution therefore verifies the differential equation.	**1**
4	In steady state, $i = I_m = \frac{E}{R+r} = 0.1$ A ; $R + r = \frac{10}{0.1} = 100$, then $\mathbf{r = 10\ \Omega}$	**0.75**
5	$i = I_m\,(1 - e^{-\frac{t}{\tau}})$, then $\frac{i}{I_m} = 1 - e^{-\frac{t}{\tau}}$, so $1 - \frac{i}{I_m} = e^{-\frac{t}{\tau}}$ We obtain: $\ell n\left(1 - \frac{i}{I_m}\right) = \frac{-1}{\tau}\times t$	**1**
6.1	see table below	**1**

t (ms)	0	0.2	0.4	0.8	1.0	1.4	1.8	2.0
i (mA)	0	18.2	33.0	55.1	63.3	75.4	83.5	86.5
$\ell n\left(1 - \frac{i}{I_m}\right)$	0	– 0.2	– 0.4	– 0.8	– 1	– 1.4	– 1.8	– 2

6.2		**0.5**
6.3	The shape of the curve is a straight line passing through the origin, its equation is of the form: $\ell n\left(1-\frac{i}{I_m}\right)$ = slope × t ; slope = $\frac{-2-0}{(2-0)\times10^{-3}} = -1000$ s^{-1} Then $\ell n\left(1-\frac{i}{I_m}\right) = -1000\,t$ (S.I)	**0.5**
7	Slope = - 1000 = $\frac{-1}{\tau}$ then $\tau = 1$ ms = 1×10^{-3} s $\tau = \frac{L}{R+r}$ so L = τ (R+r) = $1\times10^{-3}\times100$ = **0.1 H**	**0.25** **0.5**

Exercise 4 (6.5 pts) Photoelectric effect

Part	Answer	grade
1	**Statement 2**: It is the emission of electrons by a metal when exposed to electromagnetic radiation of the appropriate frequency.	**0.25**
2	According to Einstein's relation: $E_{Photon}=W_o+KE_{max}$ $KE_{max}= E_{Photon}-W_o$; $KE_{max}=h\nu - W_o$ has the form $KE_{max} = a\,\nu + b$ Therefore **a = h** and **b = -W$_o$**	**0.25** **0.5**
3.1	The curve for each metal is a **straight line** having a **positive slope** and **does not pass through the origin**, which is in agreement with the relation $KE_{max}=h\nu - W_o$; slope = h > 0	**0.5**
3.2	The two straight lines have the same slope because the slope of the straight line depends on Planck's constant h, which is constant and identical for all metals.	**0.5**
3.3	Curve (I): h = slope = $\frac{(1.41-0)\times1.6\times10^{-19}}{(9-5.5)\times10^{14}}$ = **6.44 × 10^{-34} J.s**	**0.5**
3.4	Intersection with x-axis corresponds to the threshold frequency of the metal. Using curve (I) : $\nu_{1o} = 5.5\times10^{14}$ Hz ; Using curve (II) : $\nu_{2o} = 10.4\times10^{14}$ Hz $c = \lambda_0\,\nu_0$; $\lambda_{01} = \frac{c}{\nu_{10}} = \frac{3\times10^8}{5.5\times10^{14}} = 5.45\times10^{-7}$ m = **545 nm ;** $\lambda_{02} = \frac{c}{\nu_{20}} = \frac{3\times10^8}{10.4\times10^{14}} = 2.88\times10^{-7}$ m = **288 nm**	**0.25** **0.25** **0.5** **0.25**
4	The curve (II) corresponds to zinc. Justification: λ_{1S} = 545 nm > 400 nm → **visible range** So curve (I) cannot correspond to zinc.	**0.5** **0.5**
5.1	$P = \frac{N\times E_{photon}}{\Delta t}$, so $N = \frac{P\times\Delta t}{E_{photon}}$,But $E_{photon} = \frac{h\,c}{\lambda} = \frac{6,44\times10^{-34}\times3\times10^{8}}{400\times10^{-9}} = 4.83\times10^{-19}$ J, Therefore : $N = \frac{2\times10^{-3}\times1}{4,83\times10^{-19}} \cong$ **4.14×10^{15} photons/s**	**1**
5.2	$r = \frac{n}{N}$; $n = r\times N = 0.02\times4.14\times10^{15}$ = **8.28 ×10^{13} electrons/s**	**0.25**
5.3	$I = 8.28\times10^{13}\times1.6\times10^{-19}$ =**1.32 × 10^{-5} A**	**0.5**