

()



-1

-2

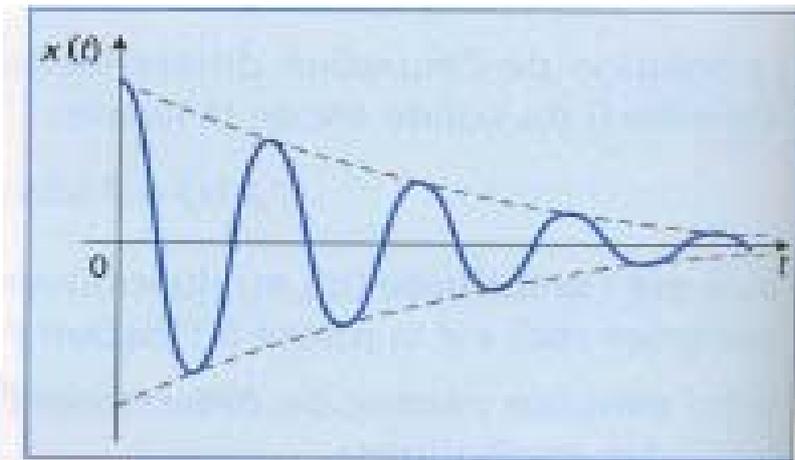
-

-

-

: -1

()



T

$$T = T_0 = 2 \pi \sqrt{\frac{m}{k}}$$

.(Oscillations forcées)

:

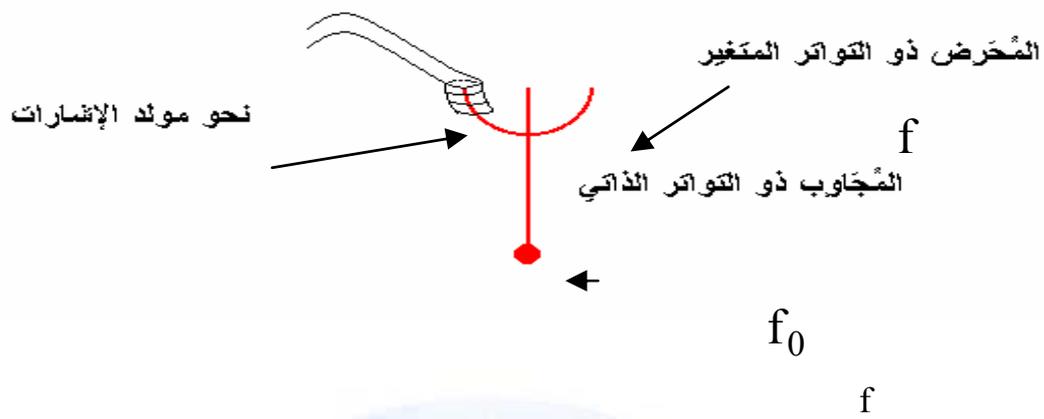
: -1-2

$$(= T_0) f_0 = \frac{1}{T_0} ()$$

f

.(Résonateur)

.(Excitateur)



f_r

:

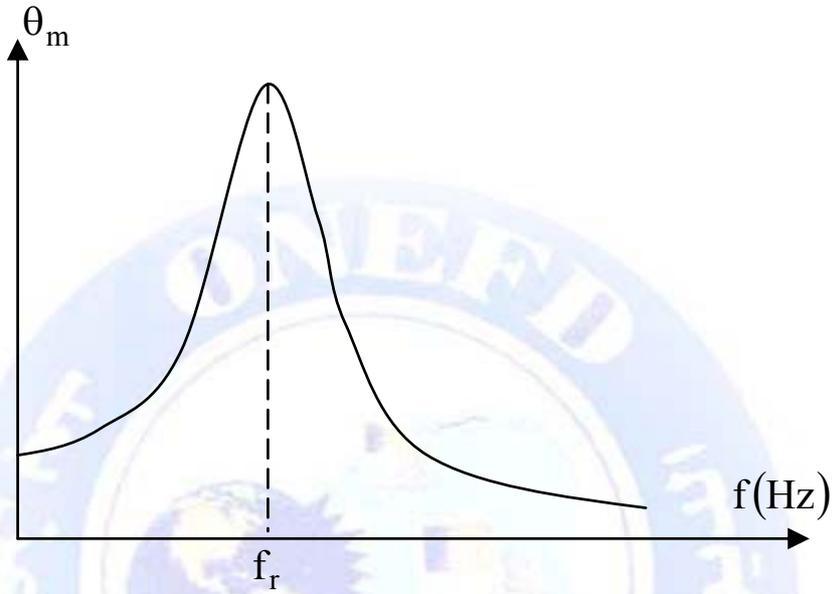
T f T

.T

f_0

f_r

.(Courbe de résonance)



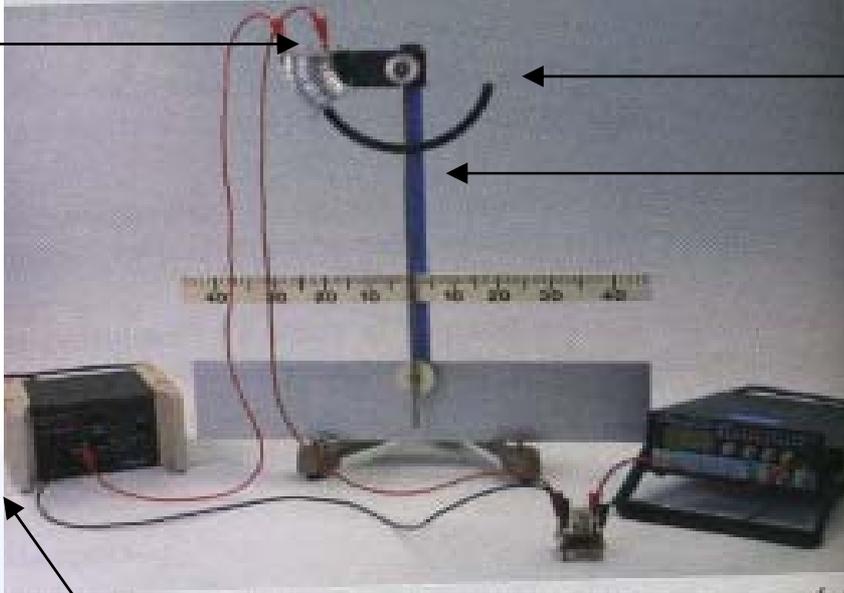
:

$f_e = \frac{1}{T_0}$	f_e	a	▪
		a	▪
			▪
			▪

-2-2 :

()

وشية



قوس حديدي

ساق

مولد التيار المستمر

مولد

المنخفضة GBF

مولد للتواترات

مولد

T_E

T_E

:

T_E

T

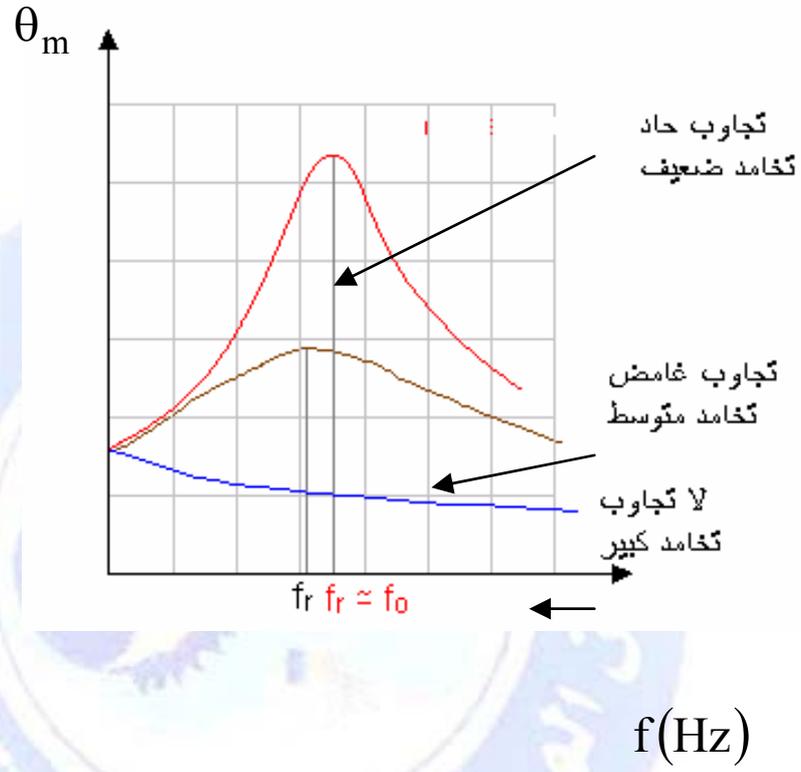
(-)

() T_E

θ_m

T

T_E



()

-3

:

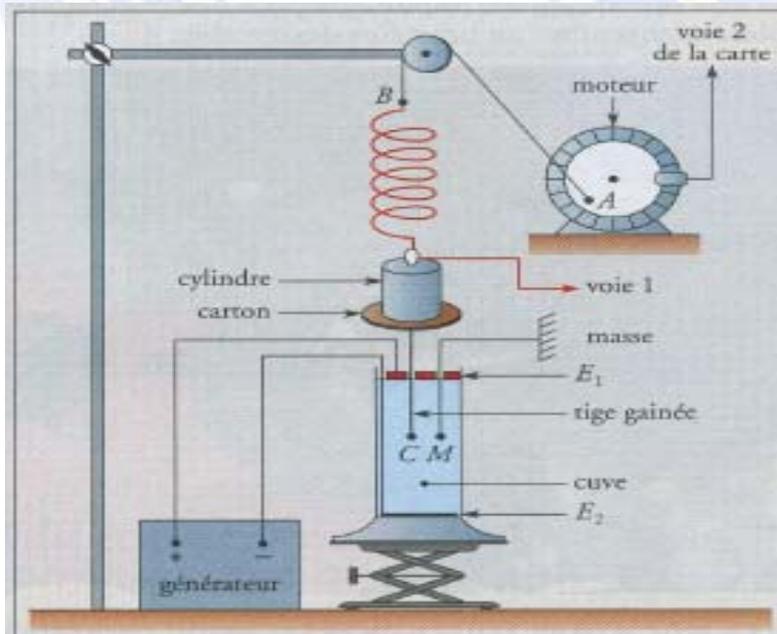
-1-3

:

(piste ondulée)



:



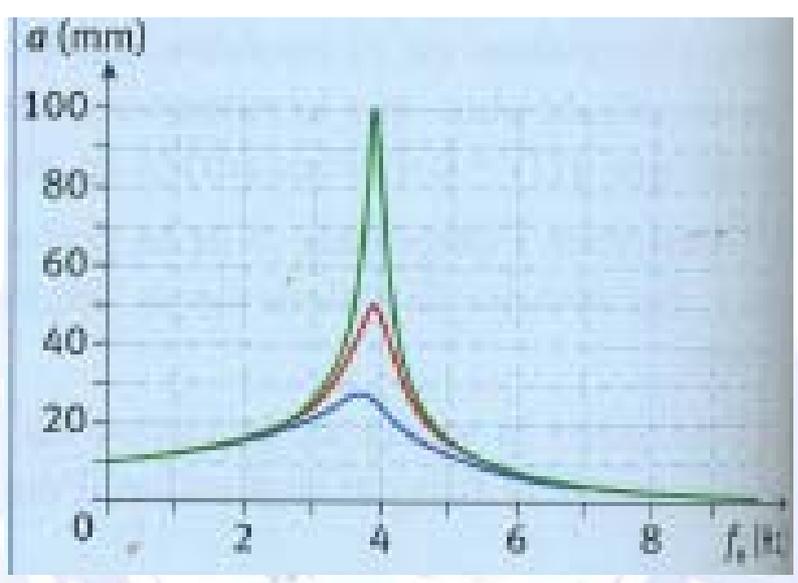
:

[(+)] f ()

f

f_r

f_r



:

f_e

a

a

f_e

▪

a

f_e

▪

.0

a

f_e

▪

:

-4

$$(f = f_0 \quad T = T_0)$$

()



:2

.le shimmy



موازنة عجلات سيارة

: 3



<http://>

جميع

6400

1995

17

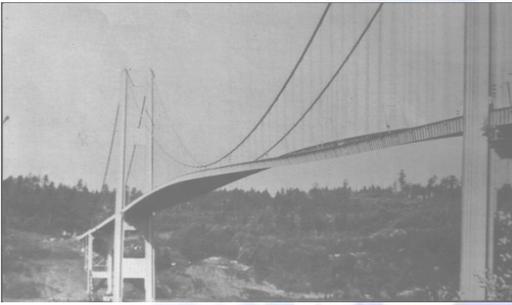
(Kobe)

:4

1940

7 (

)



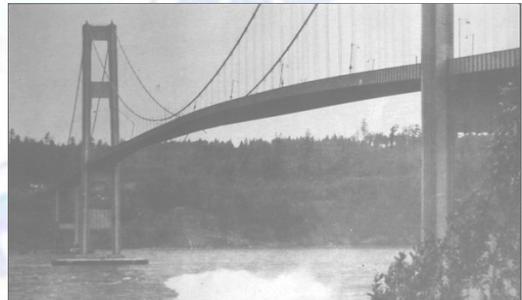
الصورة 2



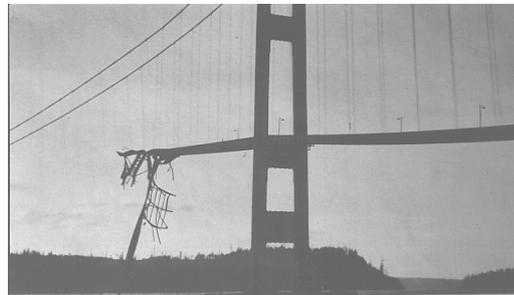
الصورة 1



الصورة 4



الصورة 3



الصورة 5

. - :

:

:
k

(ailettes)

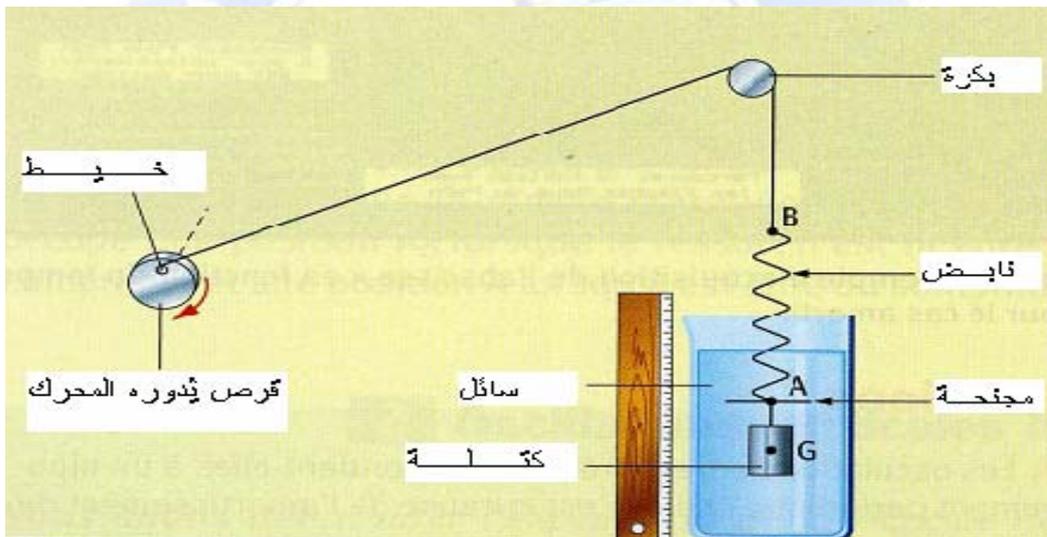
:

B

m

A

$$T \left(f = \frac{1}{T} \right)$$



B

-1

A

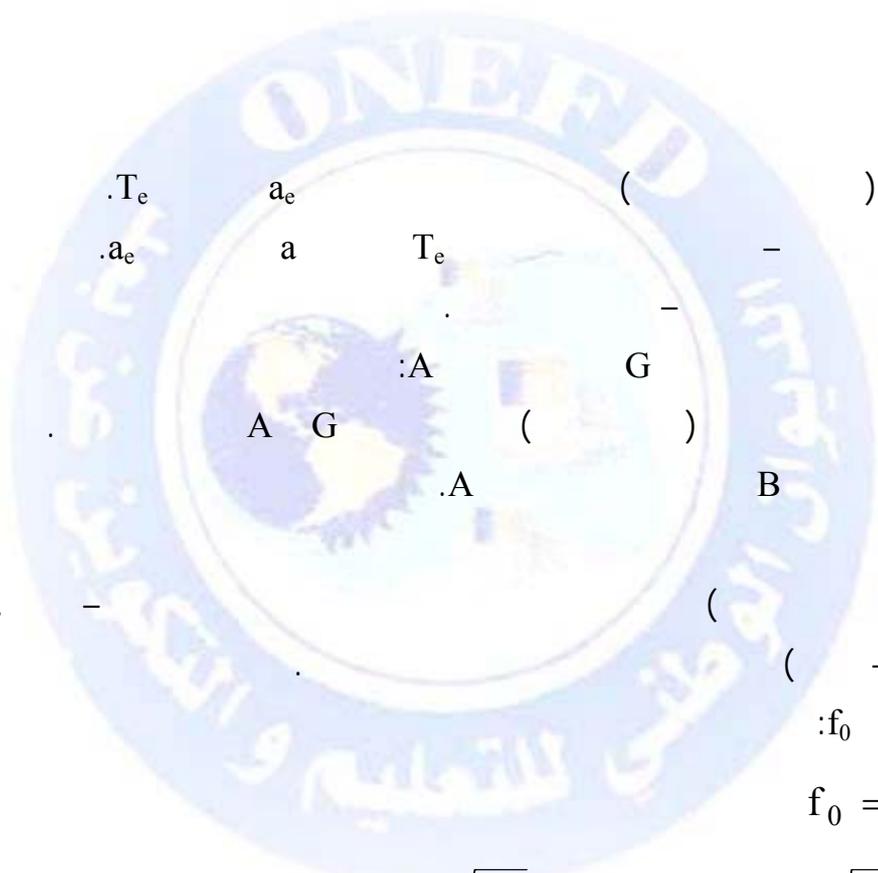
G

-2

() -3

k m · f₀ = $\frac{1}{T_0}$ -4

f f₀ -5



.T_e a_e () -1

.a_e a T_e -

:A G - -2

A G () A G -

.A B -

: -3

()

(-)

:f₀ - -4

f₀ = $\frac{1}{T_0}$:

f₀ = $\frac{1}{2\pi} \sqrt{\frac{k}{m}}$ T₀ = $2\pi \sqrt{\frac{m}{k}}$

.f₀ k m

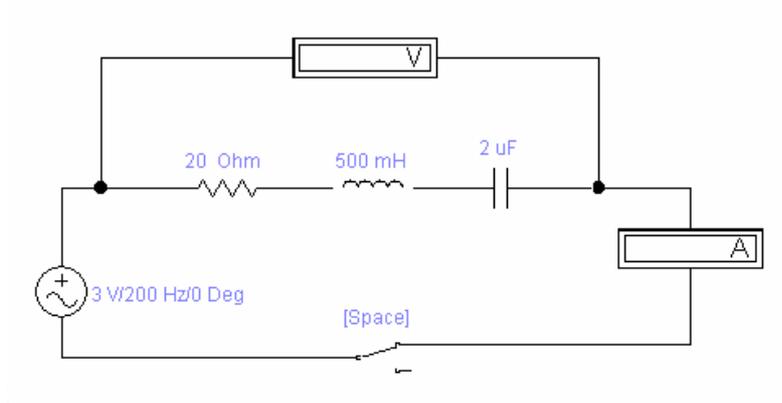
.f₀ f -

-5

.RLC

:1

: Electronics workbench



.f = 200 Hz

- 1

$U_0 (V)$	1	2	3	4	5
$I_0 (mA)$					
$(\Omega) Z = \frac{U_0}{I_0}$					

$$\frac{U_0}{I_0}$$

- 2

$$. I_0 \quad U_0$$

- 3

$$. z \quad R$$

- 4

:

:

- 1

U_0 (V)	1	2	3	4	5
I_0 (mA)	4,1	8,2	12,3	16,4	20,4
$z = \frac{U_0}{I_0}$ (Ω)	244	244	244	244	245

$$\frac{U_0}{I_0}$$

- 2

$$z : \frac{U_0}{I_0}$$

z

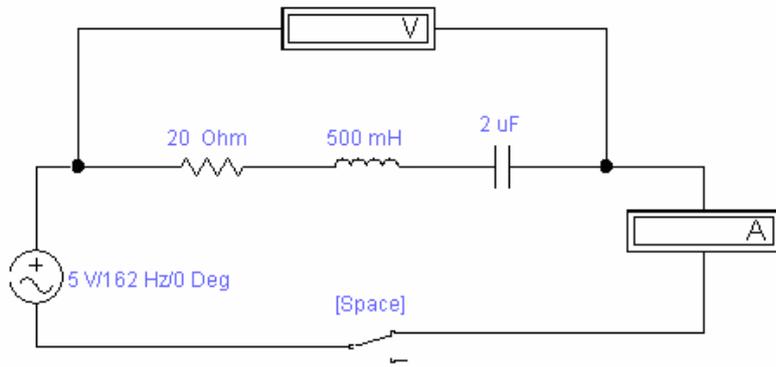
$$U_0 = z I_0 : I_0 U_0 - 3$$

$$\frac{z}{R} \approx 12 : z R - 4$$

- RLC z f :2

. Electronics workbench - 2

:



:

	U_0 (V)	1	2	3	4	5
f = 90 Hz	I_0 (mA)					
f = 158 Hz	I_0 (mA)					
f = 200 Hz	I_0 (mA)					

$I_0 = f(U_0)$: Regressi Excel /

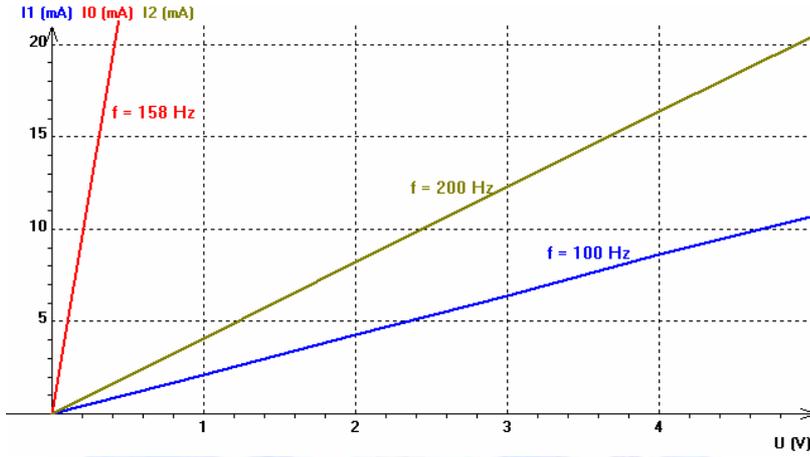
f (Hz)	100,0	158	200,0
z (Ω)			
Z/R			

$T_0 = 2\pi\sqrt{LC}$ RLC /

$\cdot f_0$.

	U_0 (V)	1	2	3	4	5
f = 90 Hz	I_0 (mA)	2,1	4,3	6,4	8,6	10,7
f = 158 Hz	I_0 (mA)	48,1	96,2	144,3	192,4	240,5
f = 200 Hz	I_0 (mA)	4,1	8,2	12,3	16,4	20,4

Regressi



f (Hz)	100,0	158,2	200,0
z (Ω)	467	21	244
Z/R	23,3	1,0	12,2

$$T_0 = 6,32 \text{ ms}$$

$$f_0 = 158,2 \text{ Hz}$$

RLC

f_0

$$z = R$$

f

RLC

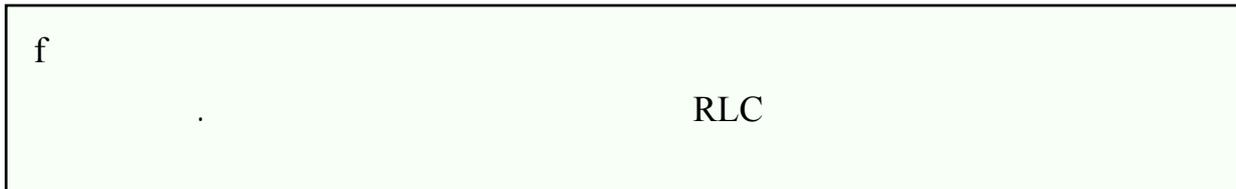
RLC

f_0

$$z > R$$

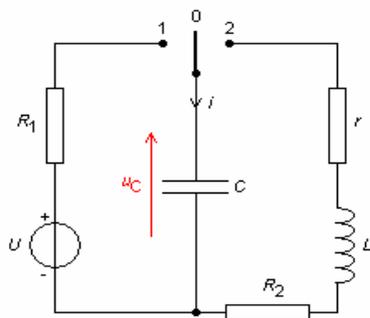
f

RLC



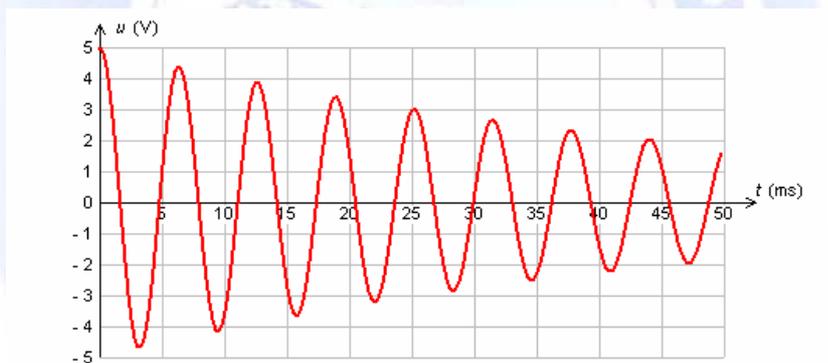
. RLC T_0 :1

: . Microméga - 1



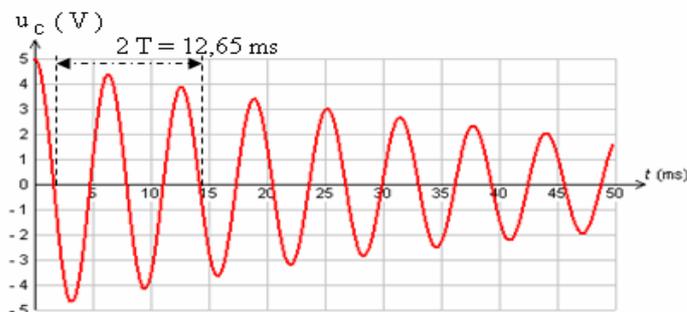
. $C = 2 \mu\text{F}$ $L = 500 \text{ mH}$ $R = R_2 + r = 20 \Omega$:

u_C 2 1



. f_0 . RLC T_0

$T_0 = 6,32 \text{ ms}$: - 1

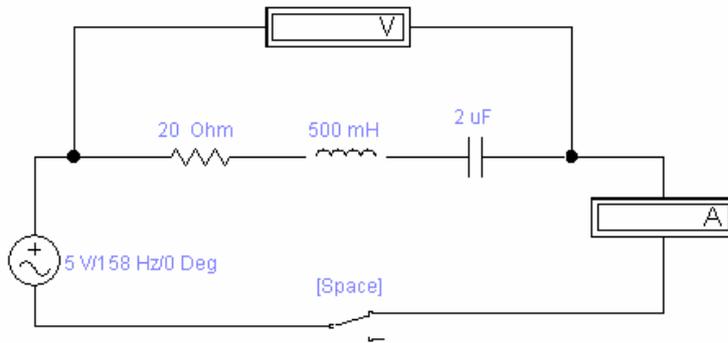


<http://www.onefd.edu.dz>

$$f_0 = \frac{1}{T_0} = 158,2 \text{ Hz}$$

جميع الحقوق محفوظة ©

.RLC z R : 2



. $f = 158 \text{ Hz}$ $U_0 = 5 \text{ V}$:

R

- 1

R (Ω)	5	10	15	20	25	30	35	40
I ₀ (mA)								
z (Ω)								

Excel

Regressi

- 2

. $z = f(R)$

- 3

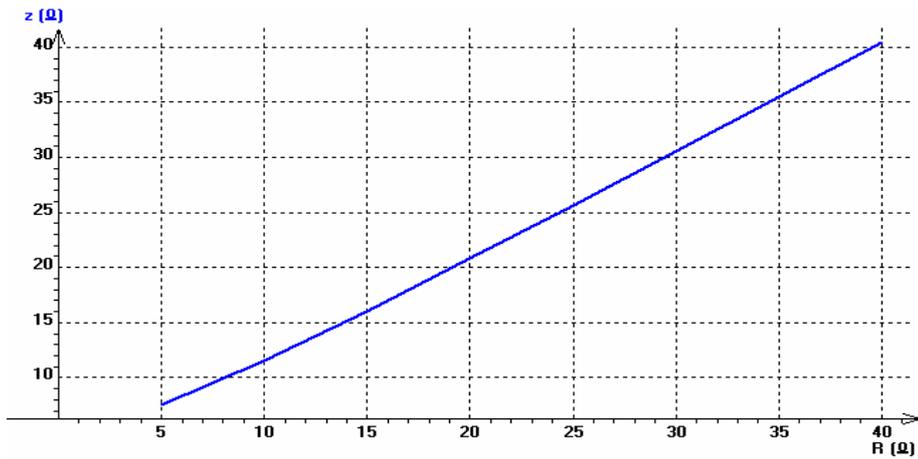
:

: - 1

R (Ω)	5	10	15	20	25	30	35	40
I ₀ (mA)	660,4	434,6	311,6	240,5	195,0	163,8	141,0	123,8
z (Ω)	7,6	11,5	16,0	20,8	25,6	30,5	35,5	40,4

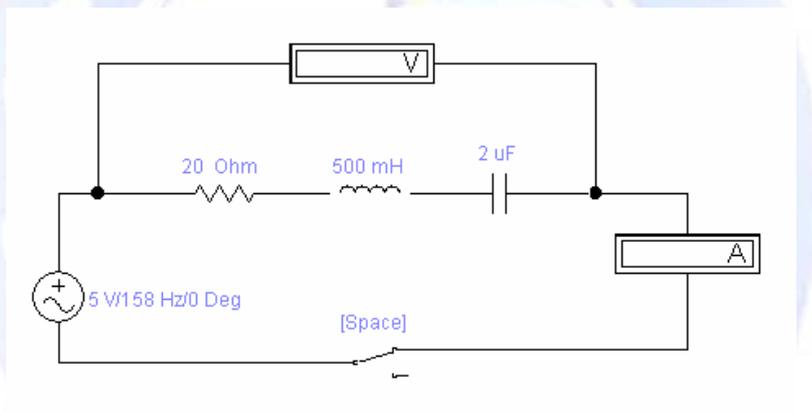
: Regressi

- 2



- 3

.RLC z L : 3



. C = 2 μF R = 20 Ω f = 158 Hz U₀ = 5 V
 . I₀ L

- 1

L (mH)	460	470	480	485	486	487	488	490	492	493
I ₀ (mA)										
z (Ω)										

494	497	500	501	502	505	510	515	520	530

. z = f (L) Excel Regressi - 2

:
: - 1

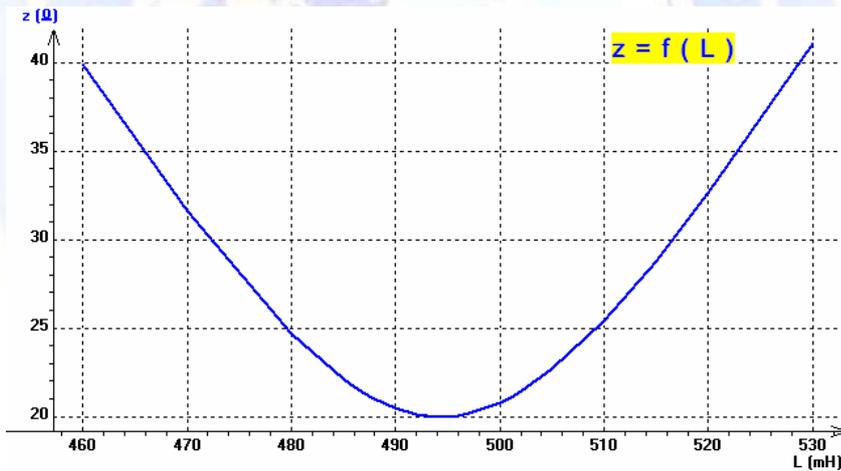
L (mH)	460	470	480	485	486	487	488	490	492	493
I ₀ (mA)	125,3	158,1	202,7	226,3	230,5	234,5	238,1	244,2	248,2	249,4
z (Ω)	39,9	31,6	27,7	22,1	21,7	21,3	21,0	20,5	20,1	20,0

494	497	500	501	502	505	510	515	520	530
249,9	247,8	240,5	237,1	233,3	220,3	196,5	173,4	153,2	121,8
20,0	20,2	20,8	21,1	21,4	22,7	25,4	28,8	32,6	41,0

: z

$$z = \frac{U_0}{I_0}$$

: Regressi z = f(L) - 2



: - 3

z = R

z = f(L)

L₀ = :

= 20 Ω

. 494 mH

L < 494 mH L > 494 mH

RLC

L₀ = 494 mH

: T <http://www.ohlcd.edu.dz>

© حقوق محفوظة $2\pi\sqrt{LC}$

$$2\pi\sqrt{LC} = 2 \times 3,14 \times \sqrt{0,494 \times 2 \cdot 10^{-6}} = 6,2 \cdot 10^{-3} \text{ s}$$

$$T = \frac{1}{f} = \frac{1}{158} = 6,3 \cdot 10^{-3} \text{ s}$$

.RLC z C :4

:

. L = 500 mH R = 20 Ω f = 158 Hz U₀ = 5 V
 . I₀ C

C (μF)	1,70	1,80	1,90	1,95	1,97	1,98	2,00	2,10	2,20	2,30
I ₀ (mA)										
z (Ω)										

- 1

Regressi

- 2

. z = f (C)

- 3

:

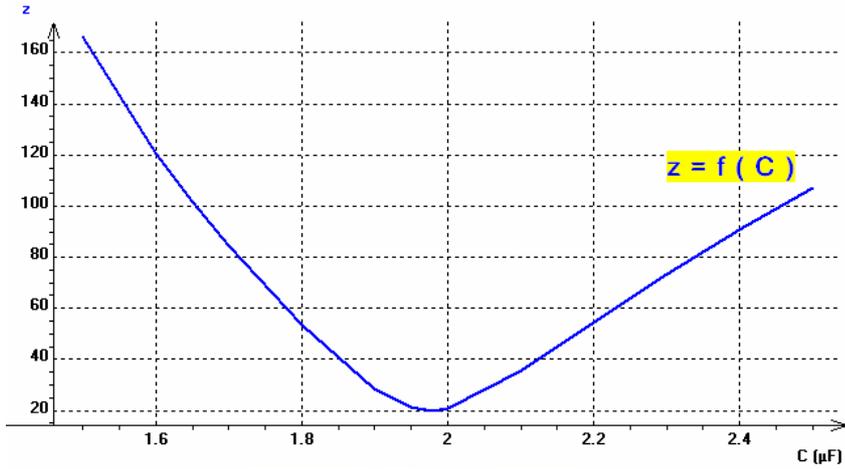
- 1

C (μF)	1,70	1,80	1,90	1,95	1,97	1,98	2,00	2,10	2,20	2,30
I ₀ (mA)	59,21	93,57	174,6	235,7	248,8	249,8	240,5	140,8	91,45	68,2
z (Ω)	84,4	53,4	28,6	21,2	20,1	20,0	20,8	35,5	54,7	73,3

- 2

:

Regressi



$z = R$: $z = f(C)$ - 3
 $C_0 = :$ $= 20 \Omega$ -
 $1,98 \mu F$ -

RLC $C < 1,98 \mu F$ $C > 1,98 \mu F$ -
 : T RLC $C_0 = 1,98 \mu F$ -
 $2 \pi \sqrt{LC}$

$$2 \pi \sqrt{LC} = 2 \times 3,14 \times \sqrt{0,5 \times 1,98 \cdot 10^{-6}} = 6,2 \cdot 10^{-3} \text{ s}$$

$$T = \frac{1}{f} = \frac{1}{158} = 6,3 \cdot 10^{-3} \text{ s}$$

- ω RLC z :4

. Electronics workbench

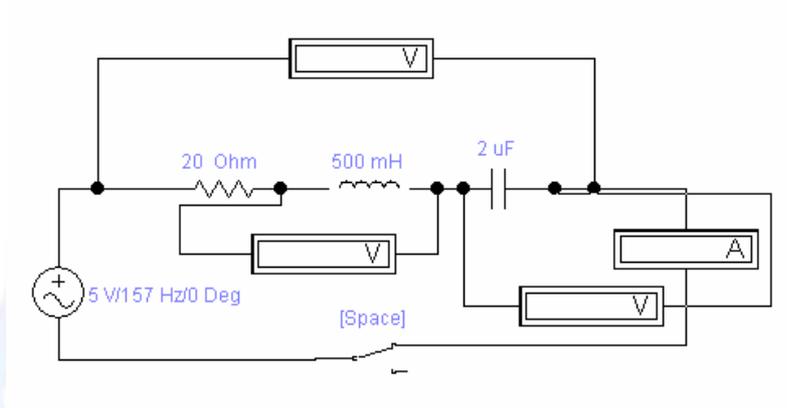
:

Q

- 7

. $f = 157,0 \text{ Hz}$ $U_0 = 5 \text{ V}$:

C L R



$$Q_2 = \frac{(U_L)_0}{U_0} \quad Q_1 = \frac{(U_C)_0}{U_0}$$

. RLC

:

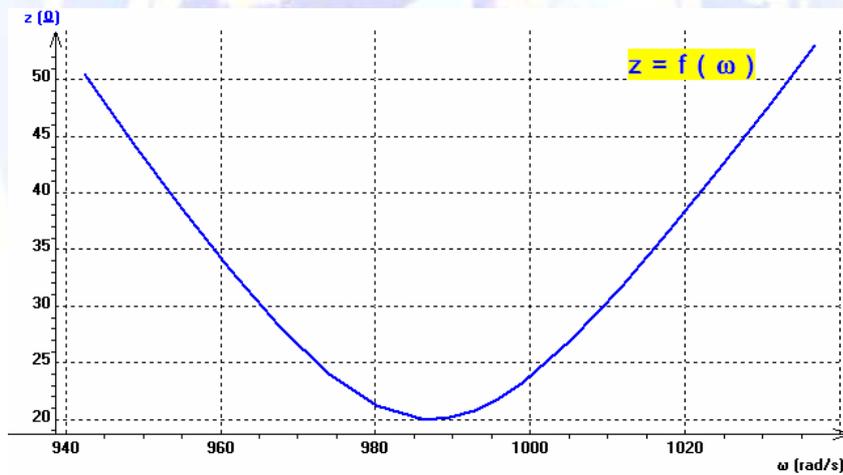
- 1

f (Hz)	150,0	151,0	152,0	153,0	154,0	155,0	156,0	157,0
I ₀ (mA)	99,1	112,6	129,5	150,7	177,0	207,2	235,7	249,8
$\omega = 2\pi f$ (Hz)	942,5	948,8	955	961,3	967,6	973,9	980,2	986,5
z (Ω)	50,45	44,40	38,61	33,18	28,25	24,13	21,21	20,02

157,5	158,0	158,5	159,0	160,0	161,0	162,0	163,0	164,0	165,0
248,1	99,1	112,6	129,5	150,7	177,0	207,2	235,7	249,8	248,1
989,6	992,7	995,9	999,0	1005,0	1012,0	1018,0	1024,0	1030,0	1037,0
20,15	20,80	21,86	23,32	27,09	31,63	36,63	41,95	47,39	52,97

.Regressi

- 2



- 3

$$z = R = 20 \Omega :$$

:

$$\omega_0 = 986,5 \text{ rad / s}$$

$$f_0 = 157,0 \text{ rad / s}$$

- 4

$$f < 157,0$$

$$i(t) \cdot z = f(\omega)$$

$$.u(t)$$

$$f > 157,0$$

$$z = f(\omega)$$

$$.u(t)$$

$$i(t)$$

$$f = 157,0$$

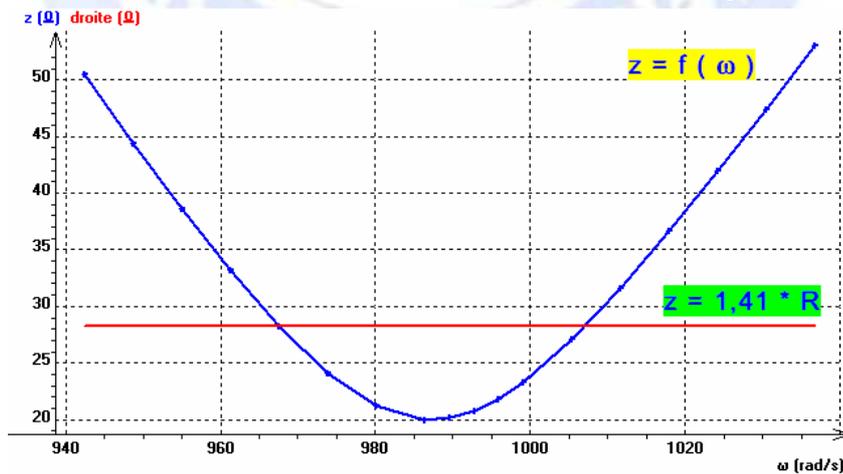
$$i(t)$$

$$.u(t)$$

- 5

$$z = R \times \sqrt{2} = 20 \times \sqrt{2} = 28,3 \text{ } \Omega$$

Regressi



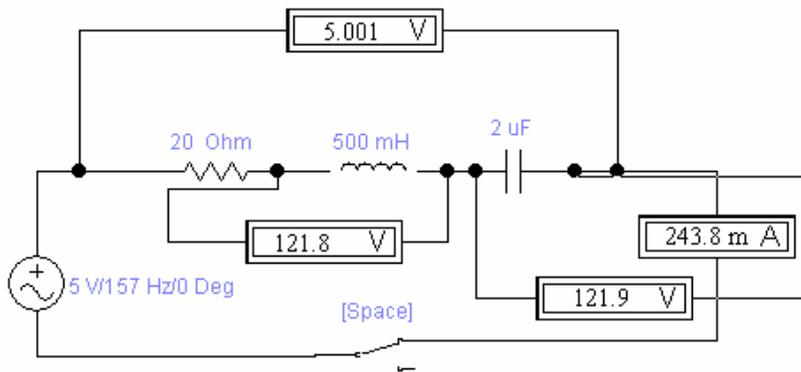
$$\omega_2 = 1000,5 \text{ rad/s} \quad \omega_1 = 967,6 \text{ rad/s}$$

$$\Delta f = \frac{\Delta \omega}{2\pi}$$

$$\Delta f = 5,2 \text{ Hz}$$

$$Q = \frac{f_0}{\Delta f}$$

$$Q = \frac{157}{5,2} = 30,2$$



$$(U_L)_0 = 121,8 \text{ V}$$

$$(U_C)_0 = 121,9 \text{ V}$$

$$Q_1 = Q_2 = 24,4$$

$$\frac{Q}{Q_1}$$

RLC

/

:

()

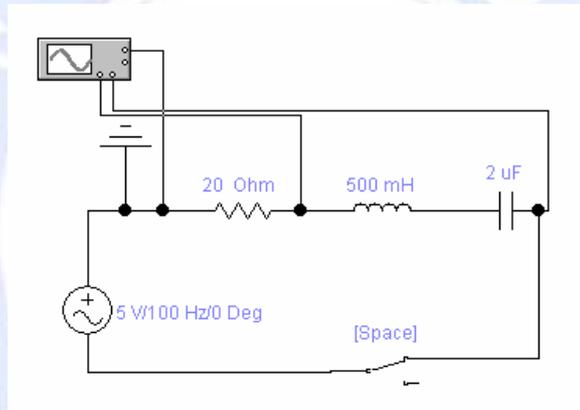
$$Q = \frac{f_0}{\Delta f} = \frac{(U_C)_0}{U_0} = \frac{(U_L)_0}{U_0}$$

()

$i(t)$ $u(t)$

Δt

f



:

RLC

f (Hz)	120	159	180
--------	-----	-----	-----

:

(y_A) R

$u_R(t)$ -

(y_B) RLC

$u(t)$ -

T_0

RLC

T

- 1

. LC

. f_0

- 2

- 3

:

:

- 1

$$T = T_0 = 2\pi\sqrt{LC}$$

:

$$T_0 = 6,28 \cdot 10^{-3} \text{ ms}$$

:

- 2

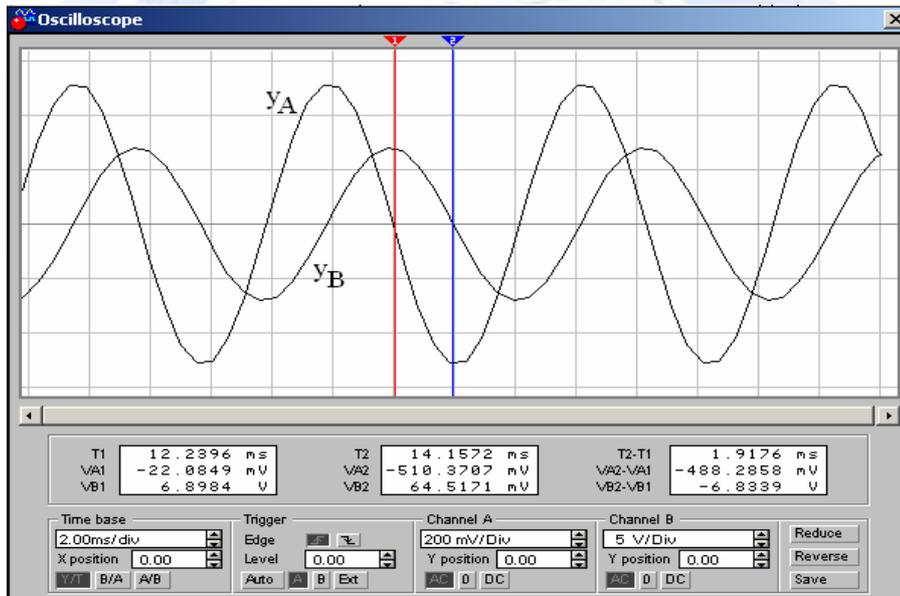
$$f_0 = \frac{1}{T_0} = 159,2 \text{ Hz}$$

- 3

f = 120 Hz

-

: $u(t) \quad u_R(t)$



$$u_R(t) = R \cdot i(t) \quad \cdot \quad u(t) \quad R(t)$$

$$\Delta t = 1,9176 \text{ ms}$$

:

f_0

f

RLC

<http://www.onefd.edu.dz>

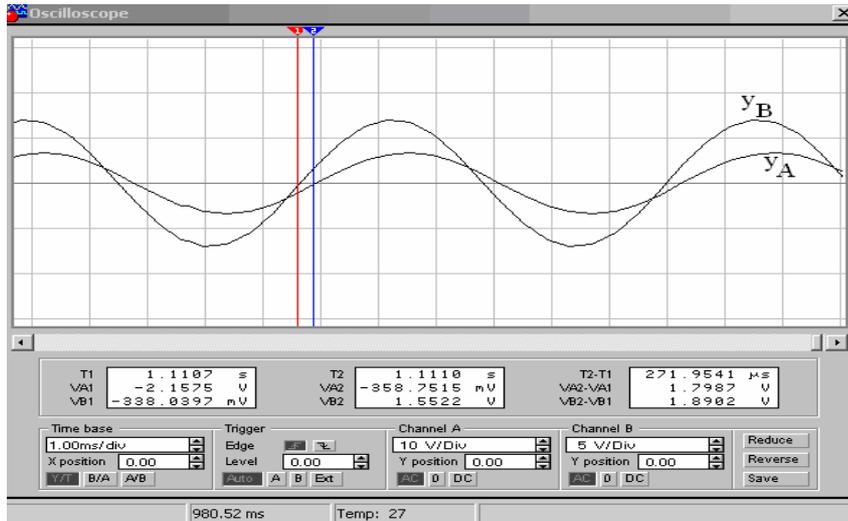
جميع الحقوق محفوظة RLC

f = 159 Hz

-

:

$$u(t) \quad u_R(t)$$



$$u(t)$$

$$u_R(t)$$

$$u_R(t) = R \cdot i(t)$$

$$u(t)$$

$$i(t)$$

$$\Delta t = 0,3 \text{ ms}$$

$$f_0$$

$$f$$

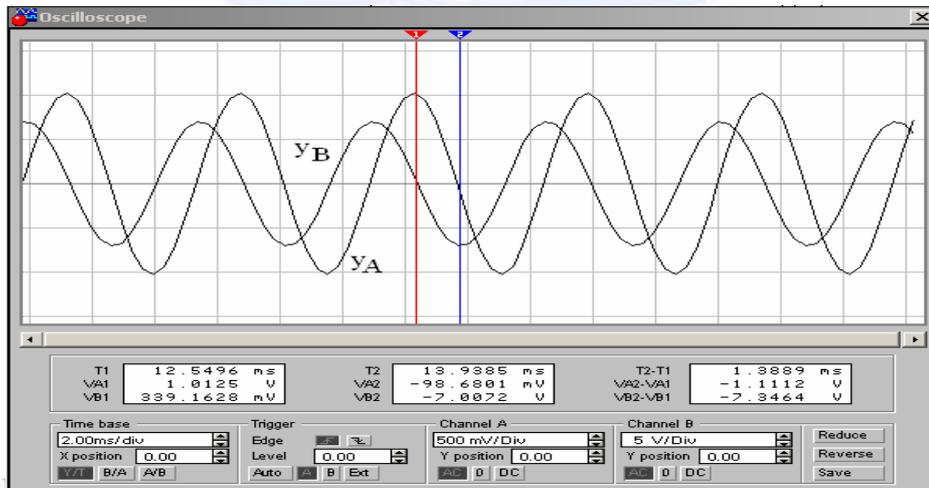
RLC

RLC

$$f = 180 \text{ Hz}$$

:

$$u(t) \quad u_R(t)$$



<http://www.onic.edu.uz>

$$u_R(t) = R \cdot i(t)$$

$$u(t)$$

$$u_R(t)$$

$$\Delta t = 1,3889 \text{ ms}$$

f_0

f

RLC

RLC

: 1

:

-1

-2

-3

-4

: 2

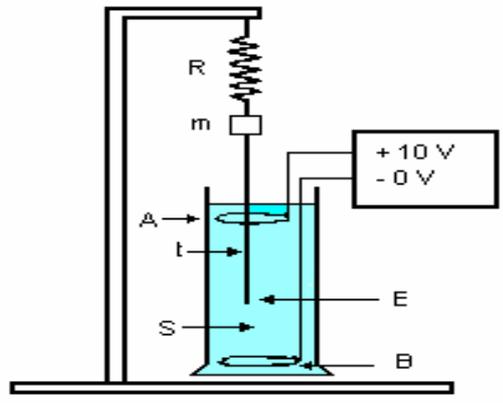
.m

k

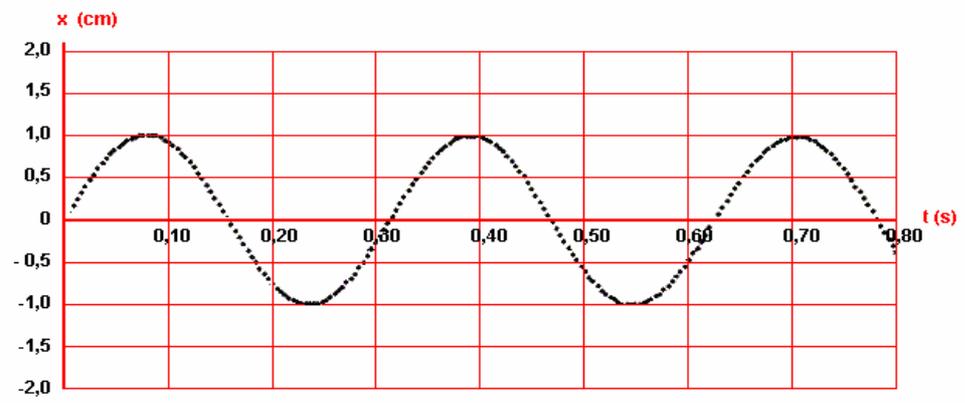
-1

$$T_0 = 2 \pi \sqrt{\frac{m}{k}}$$

-2



$k = 40 \text{ N/m}$ R
 $m = 100 \text{ g}$ m
t
m
B A
E
0 V
(
m
 $x = f(t)$



-1

T_0

-2

$$T_0 = 2\pi \sqrt{\frac{m}{k}}$$

-3

E

-4

$x = f(t)$

: 4

3

:

f(Hz)	1,5	2,0	2,5	2,8	3,1	3,2	3,3	3,6	4,0	4,5
x_{\max} (cm)	0,4	0,6	1,0	1,5	2,1	2,3	2,0	1,5	1,0	0,7

-1

$x_m = f(f)$

-2

$f = 3,2 \text{ Hz}$

-3

f_0

f_r

-4

-5

: 5

f_0

(Bosses)

() L

V_R

-1

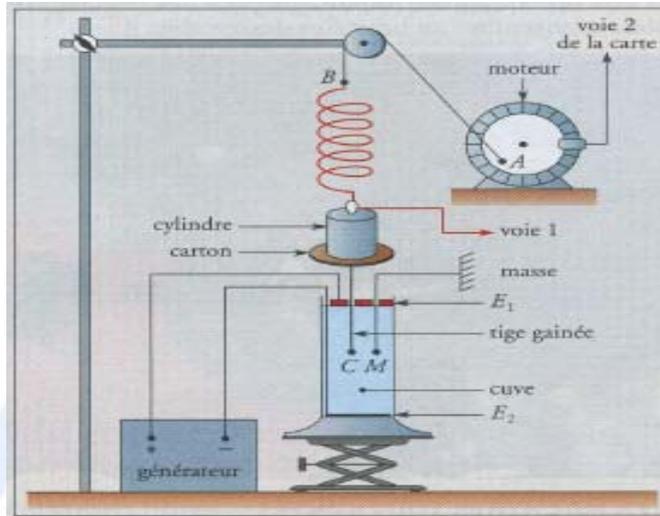
$L f_0 V_R$

-2

$L = 80 \text{ cm} \quad f_0 = 5 \text{ Hz} \quad \text{km / h} \quad V_R$

-3

: 6



:

	x_m						f_E
f_E (Hz)	1,2	1,4	1,6	1,8	1,9	2,0	2,1
x_m (cm)	1,6	2,2	3,2	4,8	5,7	6,4	6,8
f_E (Hz)	2,2	2,3	2,4	2,5	2,7	2,8	2,9
x_m (cm)	6,5	5,6	5,0	4,2	3,2	3,0	2,7

$x_m = f(f_E) : f_e$ x_m -1

f_R -2

f_R $T = 0,46$ s -3

-4

: 7

:

$R = 50 \Omega$ -

$L = 750$ mH -

$C = 10 \mu F$ -

K -

$t = 0$

:

- II

$$u(t) = 5 \sin(\omega t)$$

$i(t)$

- 1

/

I_0

z

/

:

f

/

$u(t)$

$i(t)$

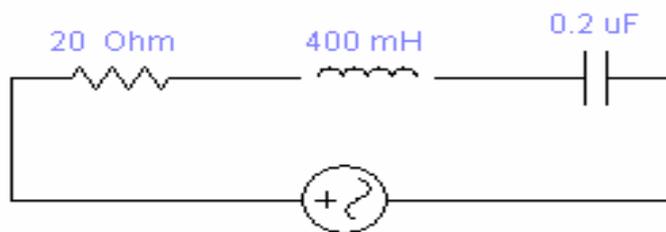
-

$u(t)$

$i(t)$

-

: 8



LC

RLC

- 1

$$f = 555,5 \text{ Hz}$$

f_0

RLC

- 2

$$I_0 = 73 \text{ mA}$$

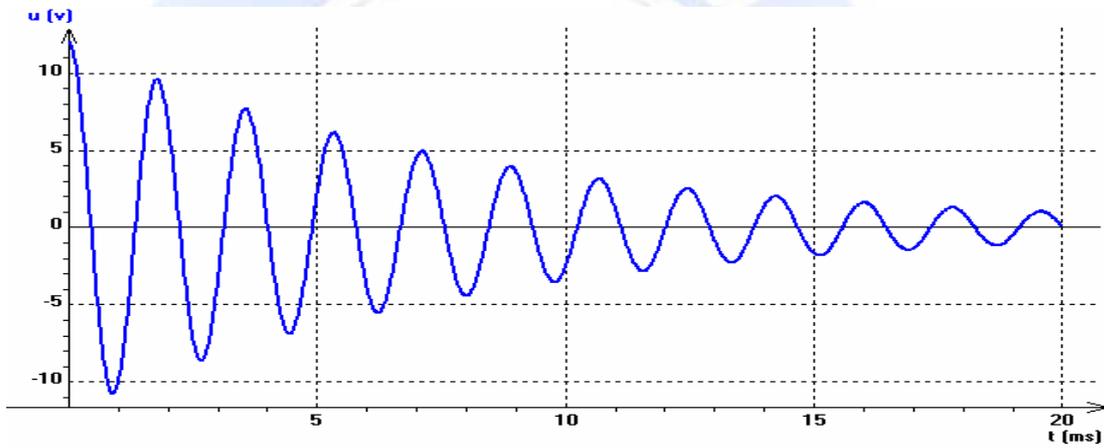
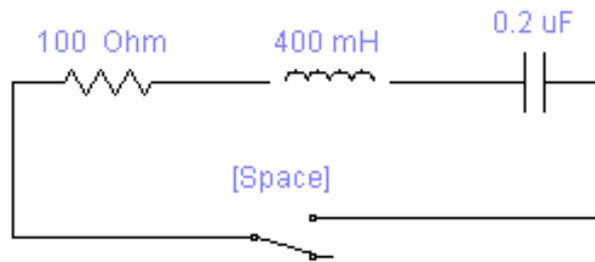
/

U_0

Δf_0

$$(U_C)_0 = 15 \text{ V}$$

/



. f_0

. RLC

-1

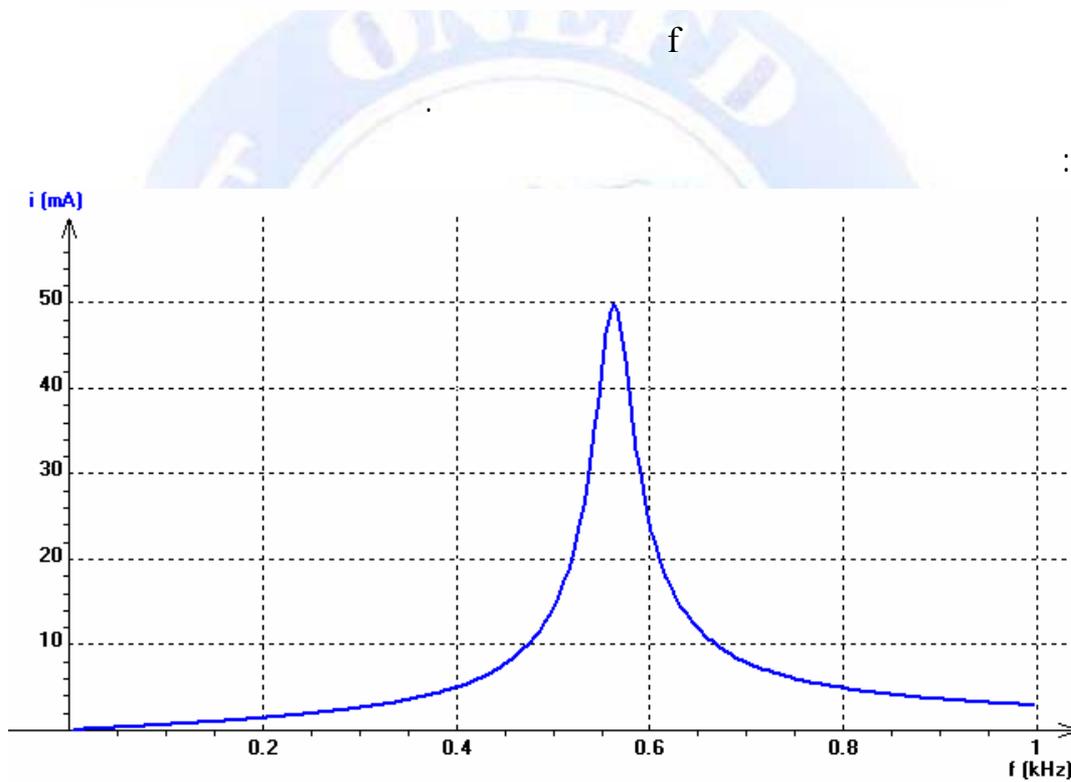
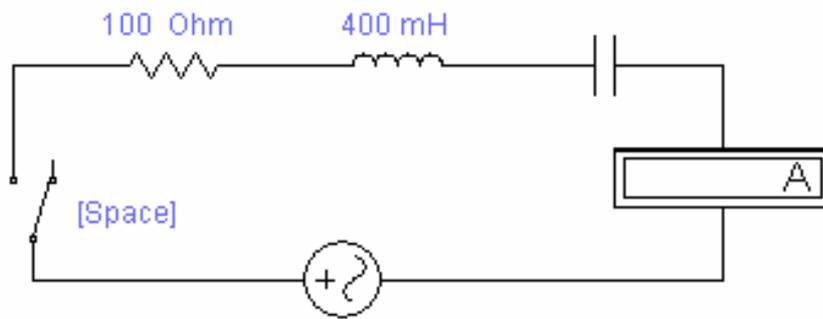
-2

$$u(t) = 2 \sin(800\pi t) :$$

/

L

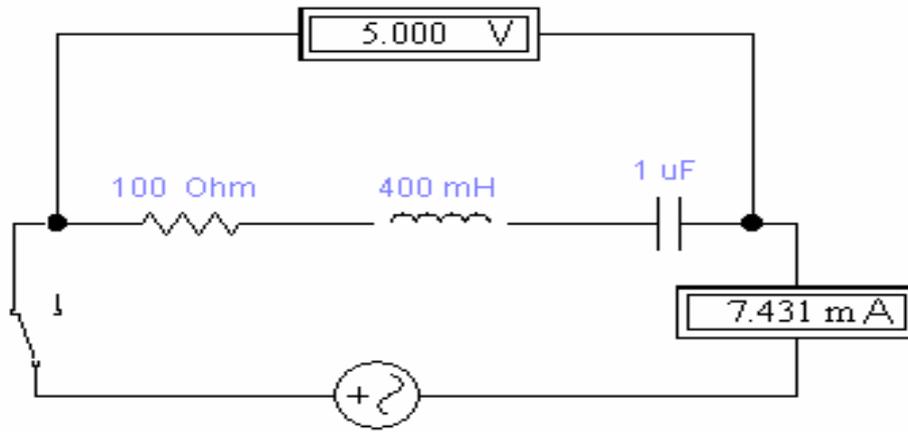
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$$I_0 = (I_0)_{\max} \sqrt{2} \quad (\Delta)$$

$$u(t) = 5 \sin(\omega t)$$

- 1
- 2
- 3
- 4
- 5
- 6



- 1
- 2



:1

.1 :

()

✓

✓

.2

.3

.4

✓

✓

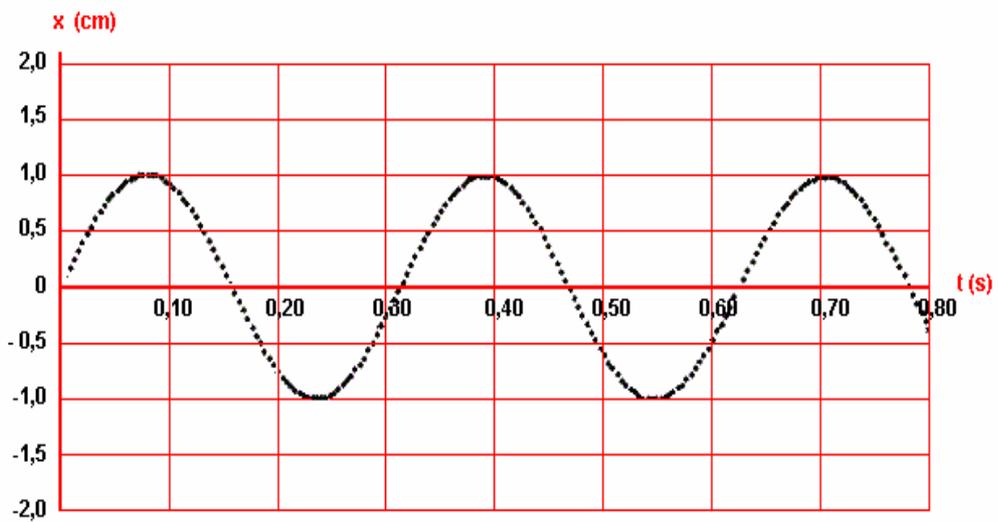
:2

-1

-2

:3

-1



htti

: -2

$$T_0 = 0,315 \text{ s}$$

: -3

$$T_0 = 2\pi \sqrt{\frac{m}{k}}$$

$$T_0 = 2\pi \sqrt{\frac{0,1}{40}} = 0,314 \text{ s}$$

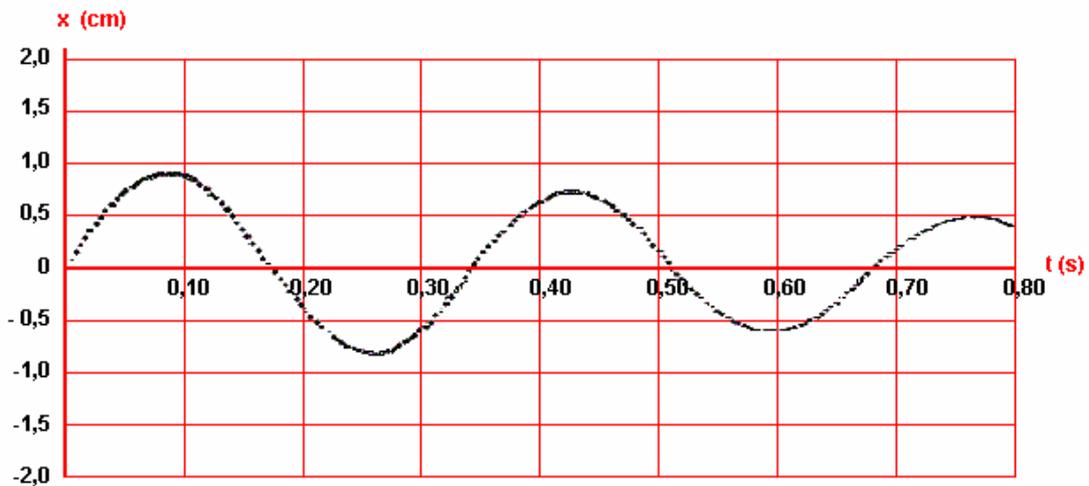
$$T_0 = 0,314 \text{ s}$$

: $x = f(t)$ -4

()

T_0

T



: 4

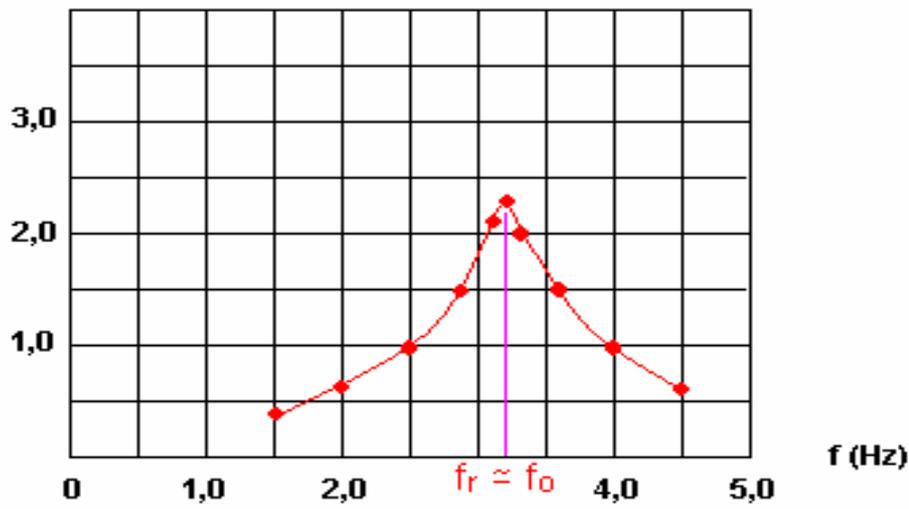
: -1

$$f_0 = \frac{1}{T_0}$$

f

: -2

x_{max} (cm)



: -3

$$f = 3,2 \text{ Hz}$$

: -4

:

$$f_0 = \frac{1}{T_0}$$

<http://www.onefd.edu.dz>

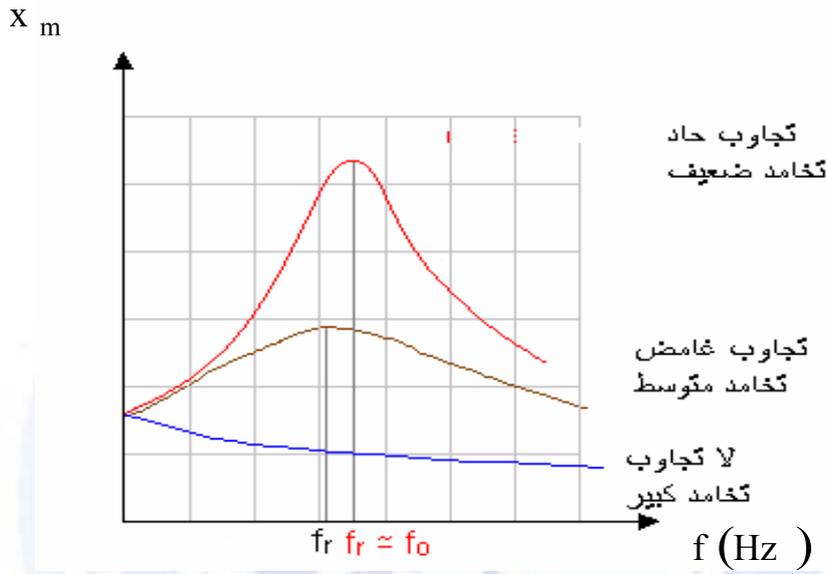
جميع الحقوق محفوظة ©

$$f_0 = \frac{1}{0,314} = 3,18 \text{ Hz}$$

$$f_0 = 3,18 \text{ Hz}$$

$$.f \approx f_0$$

-5



: 5

-1

(Impulsion)
 f_0
 f

-2

$$t = \frac{L}{V_R}$$

$$T_0 = \frac{1}{f_0}$$

$$\frac{1}{f_0} = \frac{L}{V_R}$$

$$V_R = L \cdot f_0$$

:VR -3

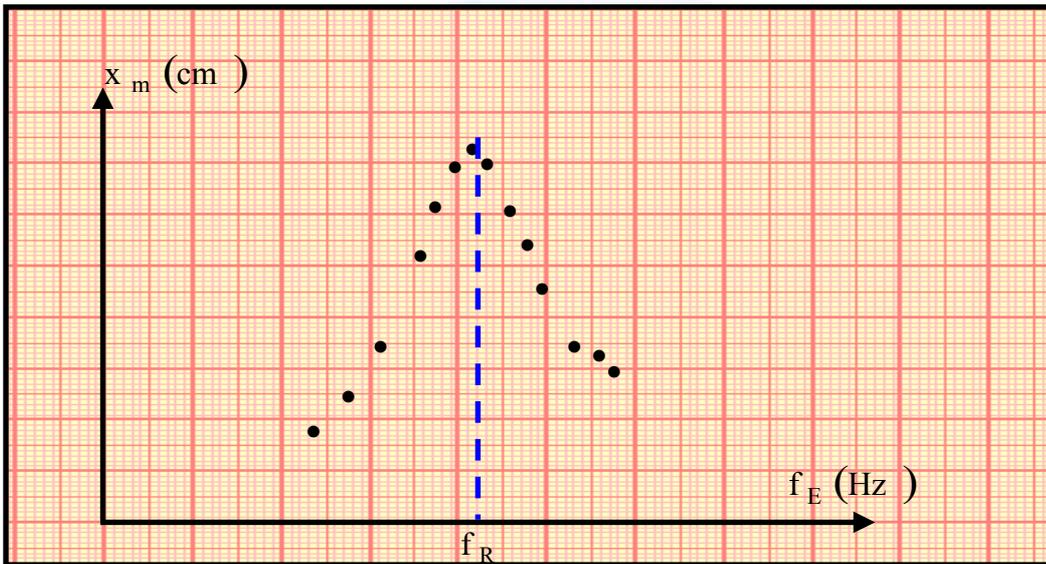
:

$$V = 0,80 \times 5 = 4 \text{ m/s}$$

$$V = 14,4 \text{ km/h}$$

:6

:xm = f(fE) -1



$$.f_R = 2,15 \text{ Hz}$$

-2

:

-3

$$f_0 = \frac{1}{T_0} \quad T_0 = \frac{1}{f_0}$$

:

$$f_0 = \frac{1}{0,46} = 2,17 \text{ Hz}$$

$$f_0 = 2,17 \text{ Hz}$$

$$f_R \approx f_0$$

: -4

()

. 6,8 cm

:7

:

LC

RLC

$$T = 2 \pi \sqrt{LC}$$

:

$$T = 17 \text{ ms}$$

:

$$f_0 = \frac{1}{T} = 58,8 \text{ Hz}$$

f

u(t)

i(t)

f₀

$$f = f_0 = 58,8 \text{ Hz}$$

:

$$z = R = 50 \ \Omega$$

$$U_0 = z \cdot I_0$$

:

$$I_0 = \frac{U_0}{z}$$

:

$$I_0 = 100 \text{ mA}$$

.u(t)

i(t)

f < 58,8 Hz

.u(t)

i(t)

f > 58,8 Hz

: 8

:

- 1

$$T = 2 \pi \sqrt{LC}$$

$$T = 1,8 \text{ ms}$$

$$f_0 = \frac{1}{T} = 555,5 \text{ Hz}$$

RLC f_0 f

$$z = R$$

$$z = 20 \text{ } \Omega$$

$$U_0 = z \cdot I_0$$

$$U_0 = 1,5 \text{ V}$$

$$\Delta t = 0 \text{ s}$$

$$Q = \frac{(U_C)_0}{U_0} = \frac{f_0}{\Delta f}$$

$$\Delta f = \frac{U_0}{(U_C)_0} f_0$$

$$\Delta f = 55,5 \text{ Hz}$$

: 9

$$T_0 = 1,8 \text{ ms} \quad - 1$$

$$f_0 = \frac{1}{T_0} = 555,6 \text{ Hz} \quad :$$

- 2

$$f = \frac{\omega}{2\pi}$$

$$f = 127,4 \text{ Hz}$$

$$f < f_0$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$L = \frac{1}{4\pi^2 C f^2}$$

$$L = 411 \text{ mH}$$

: 10

$$f_0 = 564,0 \text{ Hz} \quad I_0 = 50 \text{ mA}$$

$$T_0 = 2\pi\sqrt{LC}$$

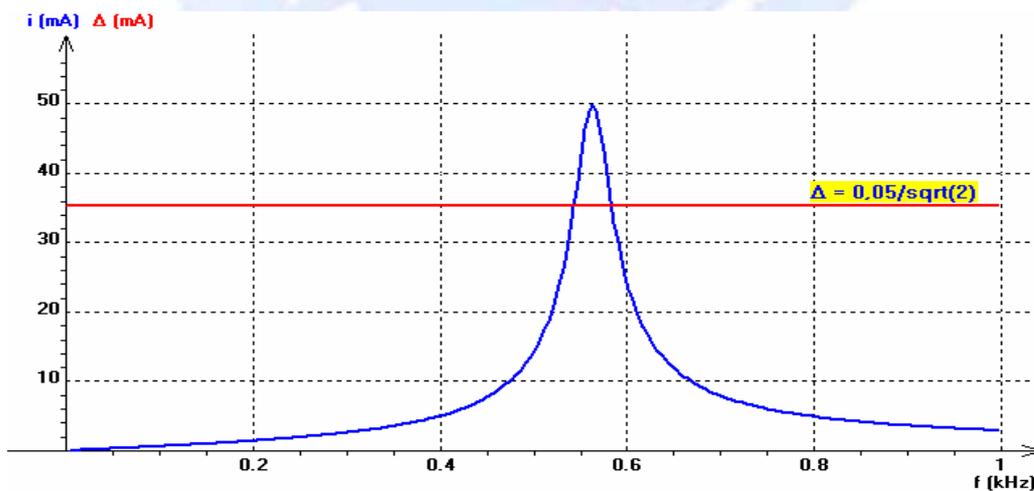
$$C = \frac{1}{4\pi^2 L f^2}$$

$$C = 0,2 \text{ } \mu\text{F}$$

- 1

- 2

- 3



- 4

$$\Delta f = 583,5 - 543,4$$

$$\Delta f = 40,1 \text{ Hz}$$

:

: 11

:

- 1

$$z = \frac{U_0}{I_0}$$

$$z = \frac{5}{7,431 \cdot 10^{-3}}$$

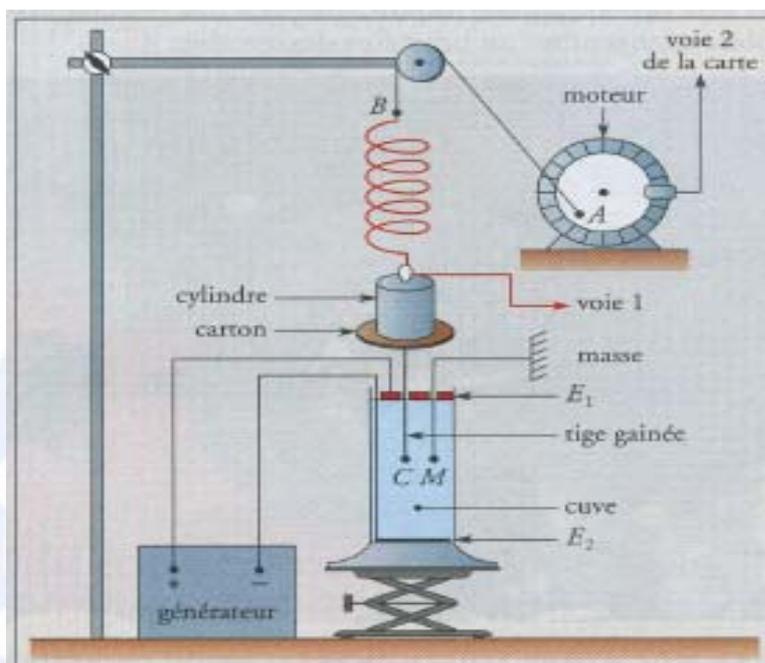
$$z = 673 \Omega$$

:

$$. z > R$$

- 2

:1



. $T_0 = 0,46 \text{ s}$

0,46 s

- 1
- 2
- 3
- 4
-
-