GPN2-L11

Problem 1

A 12 H inductor carries a current of 2.0 A. At what rate $|\frac{di}{dt}|$ must the current be changed to produce a 60 V emf in the inductor? (01小題)

$|\frac{di}{dt}|$=______ A/s

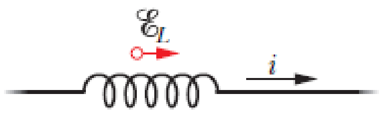
01: **ANS:=5.0**

Solution:

$\mathscr{E} = -L\frac{di}{dt}; \quad \frac{di}{dt} = \frac{\mathscr{E}}{L} = -60/12 = -5$

Problem 1

At a given instant the current and self-induced emf in an inductor are directed as indicated in the figure. (a) Is the current increasing or decreasing? (b) The induced emf is 17 V, and the rate of change of the current is 25 kA/s; find the inductance. (02小題)



(a)the current is ________ 1=increasing; 2=decreasing.

02: **ANS:=2**

(b)the inductance=_______ H

03: **ANS:=6.8E-4**

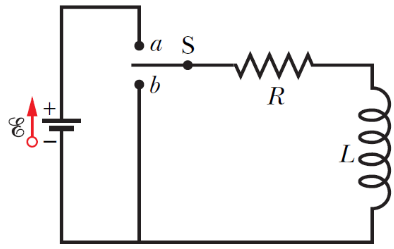
Solution:

(a)the coil wants to fight the changes—so if it wants to push current rightward (when the current is already going rightward) then i must be in the process of decreasing.

(b) $L = \frac{\mathscr{E}}{\frac{di}{dt}} = \frac{17}{2.5 \times 10^3} = 6.8 \times 10^{-4}$

Problem 2

The switch in the figure is closed on a at time $t = 0$. What is the ratio $\mathscr{E}/\mathscr{E}_L$ of the inductor's self-induced emf to the battery's emf (a) just after $t = 0$ and (b) at $t = 2.0\tau_L$? (c) At what multiple of τ_L will $\mathscr{E}/\mathscr{E}_L = 0.5$? (03小題)



(a)$t = 0, \quad \mathscr{E}/\mathscr{E}_L$=______

04: **ANS:=1**

(b)$t = 2.0\tau_L, \quad \mathscr{E}/\mathscr{E}_L$=______

05: **ANS:=0.135**

(c)t/τ_L=______

06: **ANS:=0.693**

Solution:

(a)Immediately after the switch is closed $\mathscr{E} - \mathscr{E}_L = iR$. But $i = 0$ at this instant, so $\mathscr{E} - \mathscr{E}_L = 0; \quad \mathscr{E}/\mathscr{E}_L = 1$

(b)$\mathscr{E}_L(t) = \mathscr{E}e^{-t/\tau_L} = \mathscr{E}e^{-2} = 0.135\mathscr{E}; \quad \mathscr{E}/\mathscr{E}_L = 0.135$

(c)$\frac{t}{\tau_L} = \ln\frac{\mathscr{E}}{\mathscr{E}_L} = \ln 2 \Rightarrow (t/\tau_L = \ln 2 = 0.693$

Problem 2
The current in an RL circuit builds up to one-third of its steady-state value in 5.00 s. Find the inductive time constant. (01小題)

τ_L=______ s

07: **ANS:=12.3**

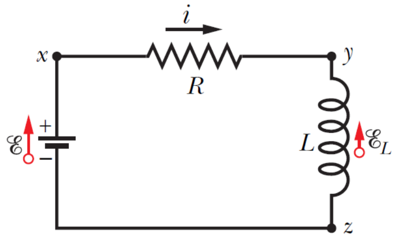
Solution:

$$i(t) = i_M\left(1 - e^{-t_0/\tau_L}\right); \quad \tau_L = -\frac{t_0}{\ln(1 - i/i_m)} = -\frac{5.0}{\ln(1 - 1/3)} = 12.3$$

nprob= 3 3

Problem 3

Suppose the emf of the battery in the circuit shown in the figure varies with time t so that the current is given by $i(t) = 3.0 + 5.0t$, where i is in amperes and t is in seconds. Take $R = 4.0\Omega$ and $L = 6.0$ H, and find an expression for the battery emf as a function of t. (01小題)



the battery emf as a function of time, $\mathscr{E}(t)$=_______ [t]

08: **ANS:=<u>42+20*t</u>**

Solution:

$$\mathscr{E} = L\frac{di}{dt} + iR = (6)(5) + (3 + 5t)(4) = 42 + 20t$$

Problem 3

For the circuit of the the figure above, assume that $\mathscr{E}=10.0V,\ R=6.70\Omega,\ L=5.50H$. The ideal battery is connected at time $t=0$. (a) How much energy is delivered by the battery during the first 2.00 s? (b) How much of this energy is stored in the magnetic field of the inductor? (c) How much of this energy is dissipated in the resistor? (03小題)

(a)the energy delivered by the battery during the first 2.00 s, $P_{battery}$=______ J

09: **ANS:=18.7**

(b)energy stored in the magnetic field of the inductor=______ J

10: **ANS:=5.10**

(c) energy dissipated in the resistor=_____ J

11: **ANS:=13.6**

Solution:

(a)$\int_0^t \frac{(E)^2}{R}\left(1-e^{-Rt/L}\right)dt=\frac{(E)^2}{R}\left[t+\frac{L}{R}\left(e^{-Rt/L}-1\right)\right]=18.7$

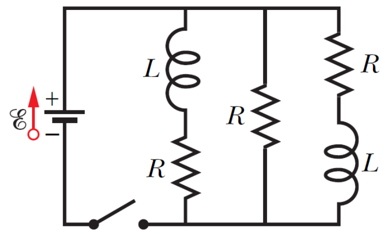
(b)$\frac{1}{2}:i^2(t)=\frac{1}{2}L\left[\frac{\mathscr{E}}{R}\right]^2()^2=5.10$

(c)heat=$18.7-5.10=13/6$

nprob= 4 4

Problem 4

The figure shows a circuit that contains three identical resistors with resistance R , two identical inductors with inductance L, and an ideal battery with emf V.
(a) What is the current i through the battery just after the switch is closed?
(b) What is the current i through the battery long after the switch has been closed? (02小題)



(a)just after the switch is closed, i=________ [R,L,V]

12: **ANS:=V/R**

(b)long after the switch is closed, i=________ [R,L,V]

13: **ANS:=(3*V)/R**

Solution:

(a)起初開關連結上時，兩個電感產生最大的感應電動勢，完全不讓電流通過，電流只能經過中間沒有電感的電阻流通，因此電池的電動勢的電位差全部跨越中間的電阻，$i = V/R$。
(b)隨著時間過去有越來越多的電流經過兩側電感的支路，最後所有電流接近飽和數值的時候，就不再變化，電感就不再有感應電動勢，因此等效電阻等於3個電阻並聯：$i = V/(R/3) = 3V/R$

__C__ 14 可嘗試次數= 1 分數= 1 那一位科學家預言自然界中存在電磁波? (A)Einstein (B)Bohr (C)Maxwell (D)Newton (E)Faraday。

__C__ 15 可嘗試次數= 1 分數= 1 關於光與電磁波的敘述，下列何者正確? (A)光波不需介質傳播，電磁波則需要介質傳播 (B)光波是電場的振動，電磁波則包括電場及磁場 (C)光波與電磁波具有相同的傳播速度 (D)光波沒有干涉現象，電磁波有干涉現象。

__A__ 16 可嘗試次數= 1 分數= 1 可見光中波長最長的光是 (A)紅光 (B)黃光 (C)藍光 (D)紫光 。

__D__ 17 可嘗試次數= 1 分數= 1 可見光中頻率最高的光是 (A)紅光 (B)黃光 (C)藍光 (D)紫光

__E__ 18 可嘗試次數= 1 分數= 1 可見光中在真空中波速最快的光是 (A)紅光 (B)黃光 (C)藍光 (D)紫光 (E)皆相同

__D__ 19 可嘗試次數= 1 分數= 2 黃色光的波長約為____公尺？(A)0.5 (B)50 (C)500×10^{-6} (D)500×10^{-9} (E)0.5×10^{-9}

__E__ 20 可嘗試次數= 1 分數= 2 X-射線的波長約為 (m)？(A)1000 (B)10 (C)10^{-1} (D)10^{-5} (E)10^{-10}

__D__ 21 可嘗試次數= 1 分數= 2 FM調頻無線電波的頻率為100 MHz，此無線電波的波長為_____ m？(A)0.01 (B)0.1 (C)0.3 (D)3 (E)10 (F)30 (G)100 (H)300

__C__ 22 可嘗試次數= 1 分數= 2 承上題，此無線電波傳播的速度為_______m/s? (A)3.43×10^2 (B)3.00×10^5 (C)3.00×10^8 (D)3.43×10^5 (E)3.43×10^8 (F)2.45×10^5 (G)2.45×10^8

__A__ 23 可嘗試次數= 1 分數= 1 承上題，此無線電波是否為電磁波? (A)是 (B)否 (C)依頻率決定 (D)依波長決定 (E)依介質決定

__B__ 24 可嘗試次數= 1 分數= 1 承上題，此無線電波傳播的物理量為何? (A)空氣的密度 (B)電場與磁場 (C)電場 (D)磁場 (E)重力波

__D__ 25 可嘗試次數= 1 分數= 1　太陽提供了太陽系所有的行星能量，它是以輻射電磁波的方式放射出能量。請問太陽所輻射的電磁波當中含量最為豐富的是哪一個波段的電磁波? (A)紅外線　(B)紫外線　(C)紅光　(D)黃光　(E)藍光　(F)無線電波

__E__ 26 可嘗試次數= 1 分數= 2　可見光的波長範圍界於下列何者之間? (A)200 mm ~ 800 mm　(B)400 mm ~ 700 mm　(C)200 μm ~ 800 μm　(D)400 μm ~ 700 μm　(E)400 nm ~ 700 nm

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__B__ 27 可嘗試次數= 1 分數= 1　所有的波動現象都必須滿足下列哪一個公式? (A)波速=波長x週期　(B)波速=波長x頻率　(C)波速=振幅x週期　(D)波速=振幅/週期　(E)波速=頻率/週期

__A__ 28 可嘗試次數= 1 分數= 1　在電磁波中電場振動的方向與磁場振動的方向有何關係? (A)互相垂直　(B)在同一條線上，方向可相反也可相同　(C)在同一條線上，方向相反　(D)在同一條線上，方向相同　(E)無特定關係

__F__ 29 可嘗試次數= 1 分數= 1　無線電波是由哪一位德國物理學家在實驗中證實他的存在? (A)馬克斯威爾　(B)波爾　(C)普朗克　(D)愛因斯坦　(E)海森堡　(F)赫茲

__D__ 30 可嘗試次數= 1 分數= 2　一個波長約為10公分的電磁波其頻率約為若干Hz? (A) 3000　(B) 3×10^5　(C) 3×10^7　(D) 3×10^9　(E) 5×10^5　(F) 5×10^7　(G) 5×10^9

__C__ 31 可嘗試次數= 1 分數= 2　波長10公分的電磁波我們稱呼為下列何者? (A)無線電波　(B)紅外線　(C)微波　(D)紫外線　(E)X-射線　(F)γ-射線

__F__ 32 可嘗試次數= 1 分數= 2　下列電磁波當中何者的頻率最高? (A)無線電波　(B)紅外線　(C)微波　(D)紫外線　(E)X-射線　(F)γ-射線

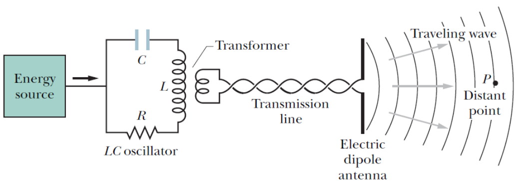
Problem 5

有一個調頻FM102.3廣播電台發射的無線電波頻率為102.3 MHz，請計算這個無線電波的波長。 (01小題)

無線電波的波長=_______ m

33: **ANS:=<u>2.930</u>**

Problem 6



What is the wavelength of the electromagnetic wave emitted by the oscillator–antenna system of the figure if $L = 0.253\,\mu$H and $C = 25.0$ pF? (01小題)

wavelength=_______ m

34: **ANS:=4.74**

Solution:

The emitted wavelength is

$$\lambda = \frac{c}{f} = 2\pi c\sqrt{LC} = 2\pi\left(2.998\times10^{8}\,\text{m/s}\right)\sqrt{\left(0.253\times10^{-6}\,\text{H}\right)\left(25.0\times10^{-12}\,\text{F}\right)} = 4.74\,\text{m}.$$

Problem 6

Following above, What inductance must be connected to a 17 pF capacitor in an oscillator capable of generating 550 nm (i.e., visible) electromagnetic waves? (01小題)

inductance, L=_____ H

35: **ANS:=5E-21**

Problem 7

A plane electromagnetic wave has a maximum electric field magnitude of 3.20×10^{-4} V/m. Find the magnetic field amplitude. (01小題)

magnetic field amplitude, B_m=______ T

36: **ANS:=1.07E-12**

Solution:

$$B_m = \frac{E_m}{c} = \frac{3.2\times10^{-4}}{3\times10^{8}} = 1.07 \times 10^{-12}$$

Problem 7

A plane electromagnetic wave traveling in the positive direction of an x axis in vacuum has components $E_x = E_y = 0$ and $E_z = 2.0\cos[(\pi \times 10^{15})(t - x/c)]$. All physical quantities are in SI units. (a) What is the amplitude of the magnetic field component? (b) Parallel to which axis does the magnetic field oscillate? (c) When the electric field component is in the positive direction of the z axis at a certain point$P$, what is the direction of the magnetic field component there? (03小題)

(a)B_m=______ T

37: **ANS:=6.7E-9**

(b)1=parallel to x-axis; 2=parallel to y-axis; 3=parallel to z-axis; Ans.=____

38: **ANS:=2**

(c) the direction of the magnetic field component=____ (1=+x; 2=-x; 3=+y; 4=-y; 5=+z; 6=-z).

39: **ANS:=4**

Solution:

(a) The amplitude of the magnetic field is

$$B_m = \frac{E_m}{c} = \frac{2.0\,\text{V/m}}{2.998\times10^{8}\,\text{m/s}} = 6.67\times10^{-9}\,\text{T} \approx 6.7\times10^{-9}\,\text{T}.$$

(b) Since the $\vec{E}$-wave oscillates in the z direction and travels in the x direction, we hav
$= B_z = 0$. So, the oscillation of the magnetic field is parallel to the y axis.

(c) The direction ($+x$) of the electromagnetic wave propagation is determined by $\vec{E}\times\vec{B}$
the electric field points in $+z$, then the magnetic field must point in the $-y$ direction.

With SI units understood, we may write

$$B_y = B_m \cos\left[\pi\times10^{15}\left(t-\frac{x}{c}\right)\right] = \frac{2.0\cos\left[10^{15}\pi\left(t-x/c\right)\right]}{3.0\times10^{8}}$$

$$= \left(6.7\times10^{-9}\right)\cos\left[10^{15}\pi\left(t-\frac{x}{c}\right)\right]$$

Problem 8
The maximum electric field 10 m from an isotropic point source of light is 2.0 V/m. What are (a) the maximum value of the magnetic field and (b) the average intensity of the light there? (c) What is the power of the source? (03小題)

(a)B_m=_____ T

40: **ANS:=6.7E-9**

(b)the average intensity of light=_____ W/m^2

41: **ANS:=5.3E-3**

(c) the power of the source=_____ W

42: **ANS:=6.7**

Solution:

(a) The magnetic field amplitude of the wave is

$$B_m = \frac{E_m}{c} = \frac{2.0\ \mathrm{V/m}}{2.998\times10^{8}\ \mathrm{m/s}} = 6.7\times10^{-9}\ \mathrm{T}.$$

(b) The intensity is

$$I = \frac{E_m^2}{2\mu_0 c} = \frac{(2.0\ \mathrm{V/m})^2}{2(4\pi\times10^{-7}\ \mathrm{T\cdot m/A})(2.998\times10^{8}\ \mathrm{m/s})} = 5.3\times10^{-3}\ \mathrm{W/m^2}.$$

(c) The power of the source is

$$P = 4\pi r^2 I_{avg} = 4\pi(10\ \mathrm{m})^2\left(5.3\times10^{-3}\ \mathrm{W/m^2}\right) = 6.7\ \mathrm{W}.$$

Problem 9

A small laser emits light at power 5.00 mW and wavelength 633 nm. The laser beam is focused (narrowed) until its diameter matches the 1266 nm diameter of a sphere placed in its path. The sphere is perfectly absorbing and has density 5.00×10^3 kg/m^3. What are (a) the beam intensity at the sphere's location, (b) the radiation pressure on the sphere, (c) the magnitude of the corresponding force, and (d) the magnitude of the acceleration that force alone would give the sphere? (04小題)

(a)beam intensity=______ W/m^2

43: **ANS:=<u>3.97E9</u>**

(b)radiation pressure=_______ Pa

44: **ANS:=<u>13.2</u>**

(c)the magnitude of the corresponding force=______ N

45: **ANS:=<u>1.67E-11</u>**

(d)the acceleration=______ m/s^2

46: **ANS:=<u>3.14E3</u>**

Solution:

(a) We note that the cross section area of the beam is $\pi d^2/4$, where d is the diameter of the spot ($d = 2.00\lambda$). The beam intensity is

$$I = \frac{P}{\pi d^2/4} = \frac{5.00\times10^{-3}\text{ W}}{\pi\left[(2.00)(633\times10^{-9}\text{ m})\right]^2/4} = 3.97\times10^9\text{ W/m}^2.$$

(b) The radiation pressure is

$$p_r = \frac{I}{c} = \frac{3.97\times10^9\text{ W/m}^2}{2.998\times10^8\text{ m/s}} = 13.2\text{ Pa}.$$

(c) In computing the corresponding force, we can use the power and intensity to eliminate the area (mentioned in part (a)). We obtain

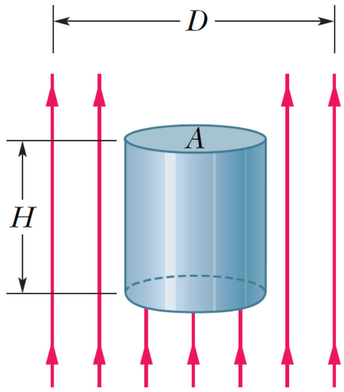
$$F_r = \left(\frac{\pi d^2}{4}\right)p_r = \left(\frac{P}{I}\right)p_r = \frac{(5.00\times10^{-3}\text{ W})(13.2\text{ Pa})}{3.97\times10^9\text{ W/m}^2} = 1.67\times10^{-11}\text{ N}.$$

(d) The acceleration of the sphere is

$$a = \frac{F_r}{m} = \frac{F_r}{\rho(\pi d^3/6)} = \frac{6(1.67\times10^{-11}\text{ N})}{\pi(5.00\times10^3\text{ kg/m}^3)[(2.00)(633\times10^{-9}\text{ m})]^3}$$
$$= 3.14\times10^3\text{ m/s}^2.$$

Problem 10

In the figure, a laser beam of power 4.60 W and diameter $D = 2.60$ mm is directed upward at one circular face (of diameter $d < 2.60$ mm) of a perfectly reflecting cylinder. The cylinder is levitated because the upward radiation force matches the downward gravitational force. If the cylinder's density is 1.20 g/cm^3, what is its height H? (01小題)



H=_____ m

47: **ANS:=4.91E-7**

Solution:

The mass of the cylinder is $m = \rho(\pi D^2/4)H$, where D is the diameter of the cylinder. Since it is in equilibrium

$$F_{\text{net}} = mg - F_r = \frac{\pi H D^2 g\rho}{4} - \left(\frac{\pi D^2}{4}\right)\left(\frac{2I}{c}\right) = 0.$$

We solve for H:

$$H = \frac{2I}{gc\rho} = \left(\frac{2P}{\pi D^2/4}\right)\frac{1}{gc\rho}$$

$$= \frac{2(4.60\,\text{W})}{[\pi(2.60\times10^{-3}\,\text{m})^2/4](9.8\,\text{m/s}^2)(3.0\times10^8\,\text{m/s})(1.20\times10^3\,\text{kg/m}^3)}$$

$$= 4.91\times10^{-7}\,\text{m}.$$