JEE MAIN SEP 2020 (MEMORY BASED) | 2ND SEP SHIFT-2

Note: The answers are based on memory based questions which may be incomplete and incorrect.

1. A rod is heated from 0ºC to 10º C. If its length changes by 0.02%, than by what will be change in mass density ?

(1) 0.02 (2) 0.04 (3) 0.06 (4) 0.08

Ans (3)

Sol. $\frac{\Delta L}{L} \times 100 = 0.02$ and $\Delta T = 10^\circ C$

$$\frac{\Delta L}{L} = 2 \times 10^{-4} = \alpha \Delta T$$

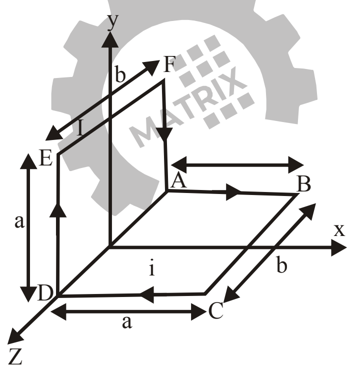
$\alpha = 2 \times 10^{-5}$

$\gamma = 3\alpha = 6 \times 10^{-5}$

$$\rho = \frac{m}{v}$$

$$\frac{\Delta \rho}{\rho} = \frac{-\Delta v}{v} = -\gamma \Delta T = -6 \times 10^{-5} \times 10$$

$$\frac{\Delta \rho}{\rho} \times 100 = -6 \times 10^{-2}$$

2. 

Magnetic moment of the loop:

(1) iab $(\hat{i} + \hat{j})$

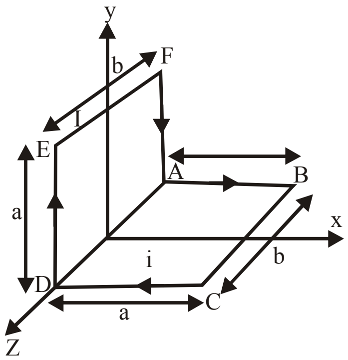
(2) iab $(-\hat{i} - \hat{j})$

(3) iab $(\hat{i} + \hat{k})$

(4) iab $(\hat{i} + \hat{j})$

Ans (2)

Sol.



Add a wire AD in which we will assume current i is flowing in both directions. Now, this loop can be considered as a combination of 2 loops i.e. ABCD & DEFA

$\bar{m}_{ABCD} = iab(-\hat{j})$

$\bar{m}_{DEFA} = iab(-\hat{i})$

$\bar{m}_{total} = iab(-\hat{i} - j)$

3. If area (A), time (T) and momentum (P) is assume as fundamental quantities, then dimensional formula of energy will be :

(1) $AT^{-2}P^{1}$ (2) $A^{1/2}T^{-1}P^{2}$ (3) $A^{1/2}T^{-1}P^{1}$ (4) $AT^{-1/2}P^{2}$

Ans (3)

Sol. $E = A^x T^y P^z$

$ML^2T^{-2} = (L^2)^x (T)^y (MLT^{-1})^z$

(i) $z = 1$

(ii) $2x + z = 2$

(iii) $y - z = -2$

From equation (i), (ii) & (iii)

$x = ½, y = -1, z = 1$

$E = A^{1/2} T^{-1} P^{1}$

4. $\vec{E}$ & $\vec{B}$ in an electromagnetic wave oscillate along the direction having unit vectors $\hat{k}$ & $\frac{\hat{i}-\hat{j}}{\sqrt{2}}$. Find unit vector along direction of propagation :

(1) $\frac{\hat{i}-\hat{j}}{\sqrt{2}}$ (2) $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$ (3) $\frac{\hat{j}+\hat{k}}{\sqrt{2}}$ (4) $\frac{\hat{j}-\hat{k}}{\sqrt{2}}$

Ans (1)

Sol. $\hat{E} = \hat{k}$

$\hat{B} = \dfrac{\hat{i} - \hat{j}}{\sqrt{2}}$

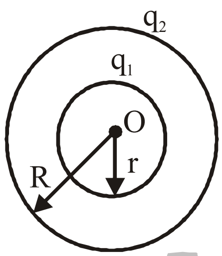
$\hat{V} = \hat{E} \times \hat{B}$

$= \dfrac{\hat{i} + \hat{j}}{\sqrt{2}}$

5. Charge Q is distributed on two concentric spheres of radius r and R respectively. If charge density of both spheres is same then electric potential at the centre will be :

(1) $KQ\left(\dfrac{1}{r} + \dfrac{1}{R}\right)$ (2) $\dfrac{KQ(r+R)}{(r^2+R^2)}$ (3) $\dfrac{KQrR}{r+R}$ (4) $\dfrac{KQ(R^2+r^2)}{(R+r)}$

Ans (2)

Sol. 

(i) $q_1 + q_2 = Q$

$\dfrac{q_1}{4\pi r^2} = \dfrac{q_2}{4\pi R^2}$

(ii) $\dfrac{q_1}{q_2} = \dfrac{r^2}{R^2}$

From (i) & (ii)

$q_1 = \dfrac{Q \times r^2}{R^2 + r^2}$, $q_2 = \dfrac{QR^2}{R^2 + r^2}$

$V_0 = \dfrac{kq_1}{r} + \dfrac{kq_2}{R}$

Putting values of q_1 and q_2

$V_0 = \dfrac{kQ(r+R)}{R^2 + r^2}$

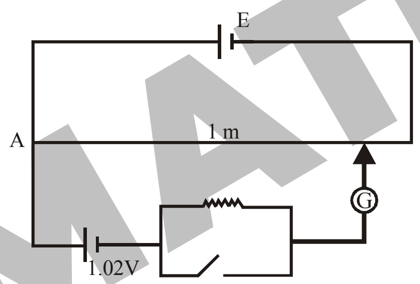
6. A capillary of radius 0.15 mm is dipped in liquid of density $\rho = 667$ kg/m^3. If surface tension of liquid is $\frac{1}{20}$ Nm^{-1} then find the height upto which liquid rises in capilary. Angle of contact between liquid and capillary tube is 60º. (g = 10 m/s^2)

(1) 0.01 m (2) 0.02 m (3) 0.04 m (4) 0.0 m

Ans (4)

Sol. $$h = \frac{2s\cos\theta}{\rho g r} = \frac{2\times\frac{1}{20}\times\cos 60^o}{667\times10\times15\times10^{-5}} = 0.05\text{m}$$

7. In given potentiometer circuit 1.02 volt is balanced at 51 cm from A. Find potential gradient of potentiometer wire AB :



(1) 0.01 volt/cm (2) 0.0 2 volt/cm (3) 0. 03 volt/cm (4) 0. 04 volt/cm

Ans (2)

Sol. Potential gradient $= \frac{dv}{dx} = \frac{1.02V}{51cm} \Rightarrow 0.02v/cm$

8. In hydrogen atom electron jumps from (n + 1)th state to nth state. The frequency of emitted photon is directly proportional to (n >> 1)

(A) n (B) $\frac{1}{n}$ (C) $\frac{1}{n^2}$ (D) $\frac{1}{n^3}$

Ans (D)

Sol. $$h\nu = (13.6\text{ eV})\left(\frac{1}{(n-1)^2} - \frac{1}{n^2}\right)$$

$$h\nu = (13.6\text{ eV})\left(\frac{1}{n^2} - \frac{1}{(n+1)^2}\right)$$

$$= (13.6\text{ eV})\left(\frac{2n+1}{n^2(n+1)^2}\right)$$

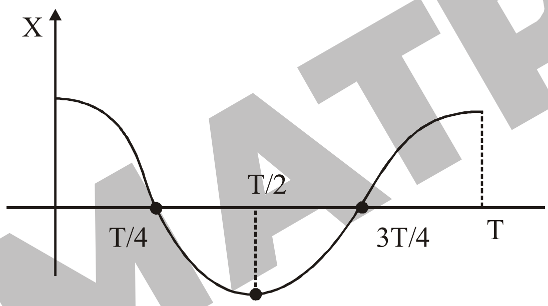
$$= (13.6\ \text{eV})\left(\frac{2+\frac{1}{n}}{n^3(1+\frac{1}{n})^2}\right)$$

n>>1

$$h\nu = (13.6\ \text{eV})\frac{2}{n^3}$$

$$\nu \propto \frac{1}{n^3}$$

9. Displacement time graph of particle performing SHM is as shown in figure. Assume that mean position is at x = 0



(1) No force is acting on the particle at $\frac{T}{4}$ (2) Speed of particle is maximum at $\frac{3T}{4}$

(3) acceleration is maximum at $\frac{T}{4}$ (4) KE and PE is equal at $t = \frac{T}{8}$

(A) 1 & 3 (B) A, C, D (C) A, B, D (D) C, D

Ans (C)

Sol. As seen from graph, equation of SHM will be given by

$x = A\cos(\omega t)$

At time $\frac{T}{4}$ & $\frac{3T}{4}$ particle is at mean position.

this means,

$F = -kx = 0$

$a = -\omega^2 x = 0$

$$v = \omega\sqrt{A^2 - x^2} = \omega A = \text{maximum}$$

At $t = \frac{T}{8}$, $x = A\cos\left(\omega \times \frac{T}{8}\right)$

$$= A\cos\left(\frac{2\pi}{T} \times \frac{T}{8}\right) = \frac{A}{\sqrt{2}}$$

$$v = \frac{1}{2}kx^2 = \frac{1}{4}\left(m\omega^2\right)A^2$$

$$k = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2\left(A^2 - \frac{A^2}{2}\right) = \frac{1}{4}m\omega^2A^2$$

$U = k$

10. A closed box contains an ideal gas. If temperature of gas is increased then which of the following is correct :

(1) Mean free path remain same (2) mean free path decreases

(3) Relaxation time decreases (4) Relaxation time remain same.

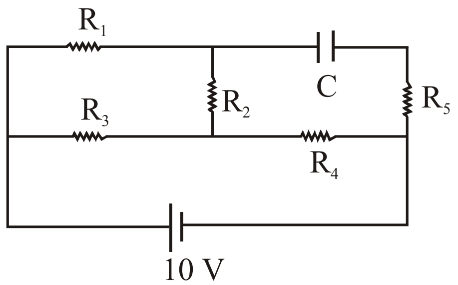
(A) 2 & 4 (B) 1 & 3 (C) 1 & 4 (D) 2 & 3

Ans (B)

S. Mean free path $= l = \dfrac{1}{\sqrt{2}\left(\dfrac{N}{V}\right)\pi d^2}$

here N = no of molecule, d $\Rightarrow$ diameter of molecule
V $\Rightarrow$ Vol. of container.
N, V, d is remain same so mean free path remain same due to increase in temperature, no of collision increase so relaxation time decrease.

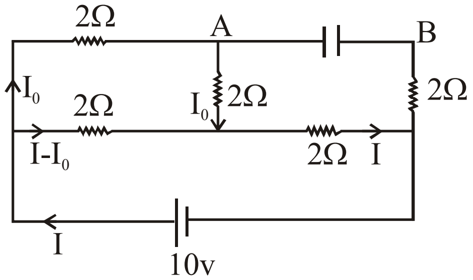
11. $R_1 = R_2 = R_3 = R_4 = 2\Omega$. Find voltage across capacitor at steady state



(A) 0 V (B) 2V (C) 4V (D) 8V

Ans (D)

S. In steady state



from KVL ⇒ $-2(I - I_0) - 2I + 10 = 0$

$2I - I_0 =$ (1)

⇒ $-2I_0 - 2I_0 + 2(I - I_0) = 0$

$I = 3I_0$ (2)

from (1) & (2) $I_0 = 1A, I = 3A$

$V_{AB} = 2I_0 + 2I$

$= 2 \times 1 + 2 \times 3 = 8V$

12. Two disc having moment of inertia $I_1 = 0.1$ kg-m^2 and $I_2 = 0.2$ kg-m^2 and angluar velocity $\omega_1 = 10$ rad/sec & $\omega_2 = 5$ rad/sec are placed over each other coaxially. Find total kinetic energy when they rotate with same angular velocity.

(A) 0 J (B) 5 J (C) 10 J (D) $\frac{20}{3}$ J

Ans (D)

Sol. Using angular momentum conservation

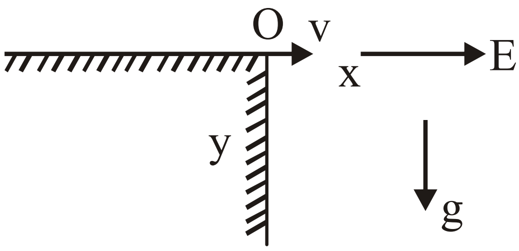
$I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$

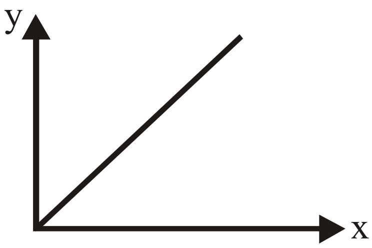
$w = \frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2} = \frac{0.1\times10+0.2\times5}{0.1+0.2} = \frac{20}{3}$

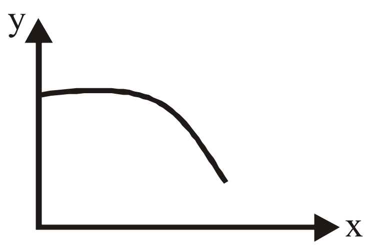
Final K.E. $= \frac{1}{2}I_1\omega^2 + \frac{1}{2}I_2\omega^2$

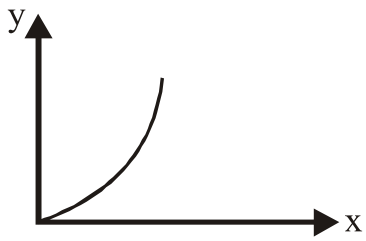
$= \frac{\omega^2}{2}(I_1 + I_2) = \left(\frac{20}{3}\right)^2 \times \frac{1}{2} \times (0.3) = \frac{20}{3}$ J

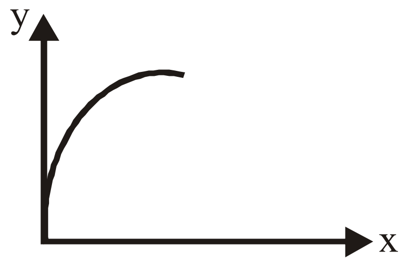
13. A particle having mass m & charge +q is projected horizontally from point O. Choose the correct graph for equation of trajectory -



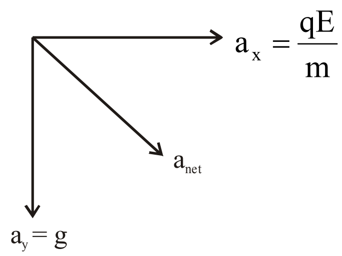
(A)


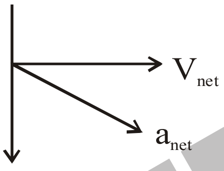
(B)


(C) 

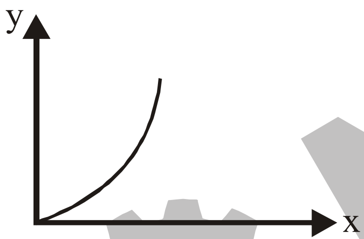
(D) 

Ans (C)

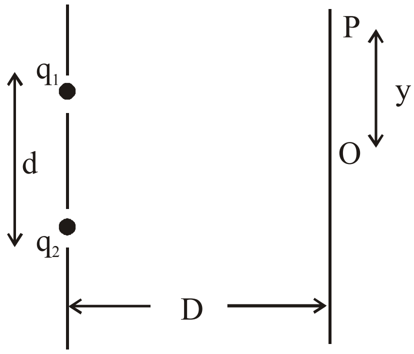
Sol. 

and 

so path of particle is parabola



14. In YDSE, when $\lambda = 700$ nm then total number of fringes between O & P is 16. When $\lambda = 400$nm then total number of fringes between O & P is



(A) 14 (B) 28 (C) 7 (D) 12

Ans (B)

S. for $\lambda = 700$ nm $\quad y = \frac{(16)D(700)}{d}$ (1)

for $\lambda = 400$nm $\quad y = \frac{n\,D(400)}{d}$ (2)

form (1) & (2) $\Rightarrow n = \frac{700 \times 16}{400} = 28$

15. Acceleration due to gravity is same at height h from surface and at depth h from the surface, then find the value of h.

(A) $\left(\sqrt{5}-1\right)\frac{R}{2}$ (B) $\frac{\sqrt{5R}}{2}-1$ (C) $\frac{R}{\sqrt{2}}$ (D) $\frac{\sqrt{5R}+R}{2}$

Ans (A)

S. $\Rightarrow \frac{GM}{(R+h)^2}=\frac{GM}{R^3}$

$\Rightarrow R^3 = (R+h)^2 (R-h)$

$\Rightarrow R^3 = R^3 - h^3 - h^2R + hR^2$

$\Rightarrow h^3 + h^2R - hR^2 = 0$

$h(h^2 + hR - R^2) = 0$

$h = 0, \frac{-R \pm \sqrt{5}R}{2}$

$h = \frac{-R+\sqrt{5}R}{2}$

16. Efficiency of cyclic process is 50%. If heat $Q_1 = 1915J$, $Q_2 = -40J$, $Q_3 = 125J$, then Q_4 is unknown then find the value of Q_4.

(1) 1080 J (2) –980 J (3) –1080 J (4) –1280 J

Sol. $\mu = \frac{W}{\sum Q_+} = \frac{Q_1+Q_2+Q_3+Q_4}{Q_1+Q_3} = 0.5$

$\Rightarrow \frac{1915-40+125+Q_4}{1915+125} = 0.5$

$\Rightarrow 1915-40+125+Q_4 = 1020$

$\Rightarrow Q_4 - 1020 - 2000$

$\Rightarrow Q_4 = -980\,J$

17. Impedance of L - R Circuit is 100 Ω and phase difference between source voltage and source current is 45°. If frequency of source 1000 Hz then inductance of coil will be.

(1) $25\sqrt{2}$mH (2) $\frac{50\sqrt{2}}{\pi}$mH (3) $\frac{25\sqrt{2}}{\pi}$mH (4) $\frac{20\sqrt{2}}{\pi}$mH

Ans (3)

S. $\tan 45° = \frac{X_L}{R} \Rightarrow X_L = R$ (1)

$Z = \sqrt{X_L^2 + R^2} = 100$

from (1)

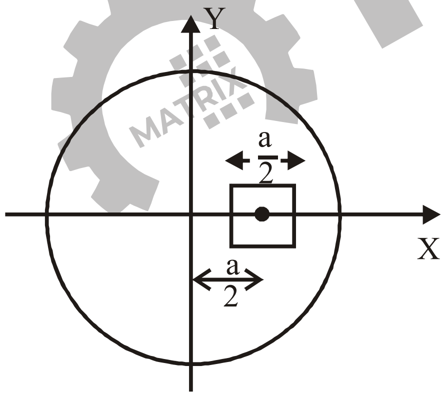
$\sqrt{2}\ R = 100$

$R = 50\sqrt{2} = X_L$

$X_L = \omega L = 50\sqrt{2}$ $\left[\frac{2\pi}{\omega} = \frac{1}{f} = \frac{1}{1000}\right]$

$L = \frac{50\sqrt{2}}{2\pi \times 1000} = \frac{25\sqrt{2}}{\pi}$mH

18. A square of side $\frac{a}{2}$ is removed from a disc having radius a. Find centre of mass of remaining portion.



(1) $X = \frac{-2a}{\pi}$ (2) $\frac{-a}{8\pi - 2}$ (3) $\frac{-4a}{3\pi}$ (4) $\frac{-a}{3\pi - 4}$

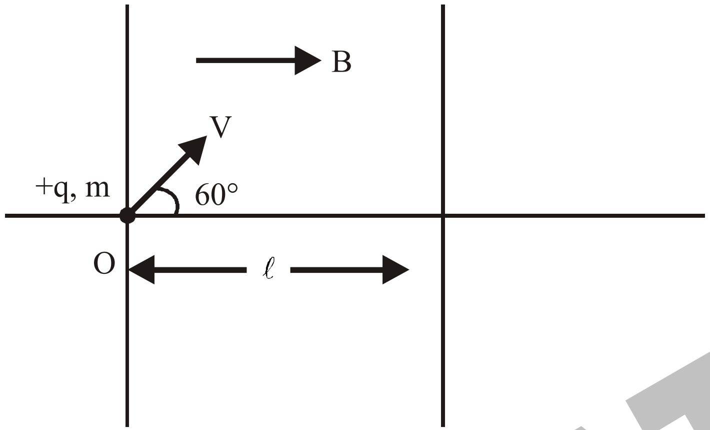
Ans (2)

S. $X = \frac{M_{complete} X_{complete} - M_{removed} X_{removed}}{M_{complete} - M_{removed}}$

$= \frac{(\sigma\pi a^2)(0) - (\sigma \frac{a^2}{4}) \times \frac{a}{2}}{\sigma(\pi a^2) - (\sigma \frac{a^2}{4})}$

$= \frac{-a^3/8}{(\pi - 1/4)} = \frac{-a}{8\pi - 2}$

19. A particle is projected with velocity v from point O. Particle complete 10 revolutions before coming out from magnetic region. Then find ℓ.



(1) $\frac{\pi mv}{qB}$ (2) $\frac{2\pi mv}{qB}$ (3) $\frac{10\pi mv}{qB}$ (4) $\frac{40\pi mv}{qB}$

Ans (3)

Sol. $\ell = 10(\text{pitch})$

$= 10\left[v\cos 60° \times \frac{2\pi m}{qB}\right]$

$\ell = \frac{10\pi mv}{qB}$

20. Young modulus of a string of length 1m and density 900 kg/m^3 is 9×10^9 N/m^2. Find minimum resonance frequency (in Hz) can be produced in the string if strain in the string is 4.9×10^{-4}.

Ans **35 Hz**

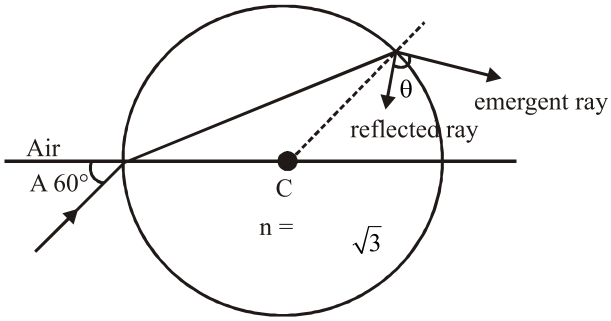
Sol. $f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}}$ and $\mu = \rho A$, $Y = \frac{T/A}{\Delta\ell/\ell} \Rightarrow \frac{T}{A} = \frac{Y\Delta\ell}{\ell}$

So $f = \frac{1}{2\ell}\frac{\sqrt{Y\Delta\ell}}{\rho\ell}$

$= \frac{1}{2\times 1}\sqrt{\frac{9\times 10^9 \times 4.9\times 10^{-4}}{100}}$

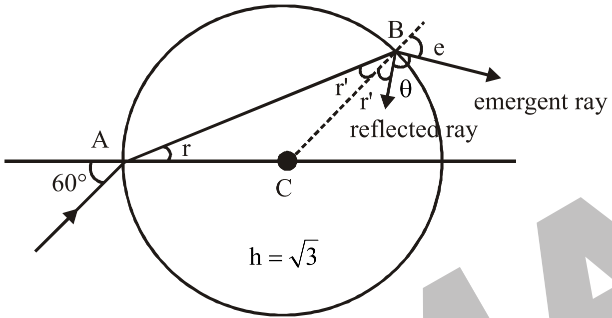
$= \frac{70}{2} = 35\text{Hz}$

21. Light incident on a sphere of refractive index $\sqrt{3}$ placed in a air as shown in figure. Find the angle (θ) in degree between emergent ray and reflected ray.



Ans $\theta = 90°$

Sol.



Apply Snell's law at A

$1 \sin 60° = \sqrt{3}\ \sin r$

$r = 30°$

In ΔABC AC = BC So r = r' = 30°

Again apply snell's law on B

$\sqrt{3}\ \sin r' = 1 \sin e$

$e = 60°$

from geometry $r' + \theta + e = 180°$

$\theta = 90°$

22. A capacitor of capacity $20\,\mu F$ is charged up to 50V and disconnected from cell. Now this charged capacitor is connected to another capacitor of capacitance C. If final common potential is 20V then find the capacitance C in μF.

Ans **30**

S. Common potential $= 20 = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$$20 = \frac{20 \times 50 + C \times 0}{20 + C}$$

$$400 + 20C = 1000$$

$$C = 30\ \mu F$$