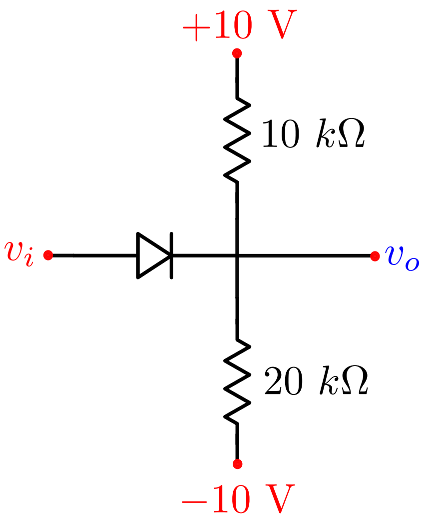
*Question 1:*

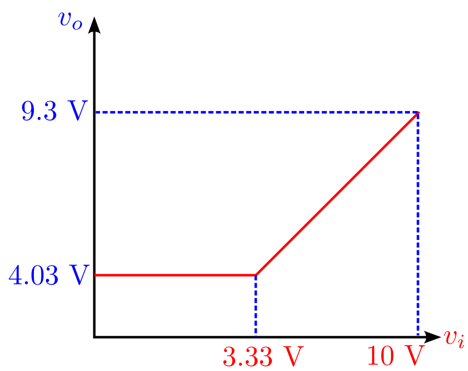
*The diodein the circuit shown in the figure has a forward voltage drop* $(V_d)$ *of 0.7 V. The input voltage swing is in the range*

$$-10\,V \leq v_i \leq 10\,V$$

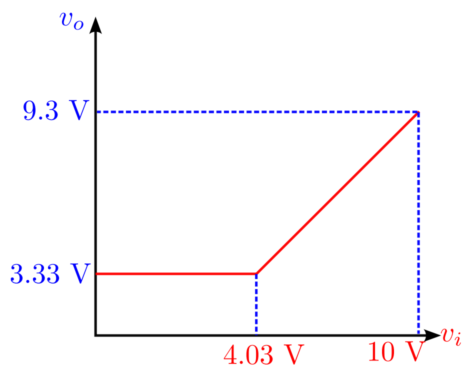
*Which of the following plots describes the input-output relation (plot of* $v_o$ *versus* $v_i$*) of the circuit*



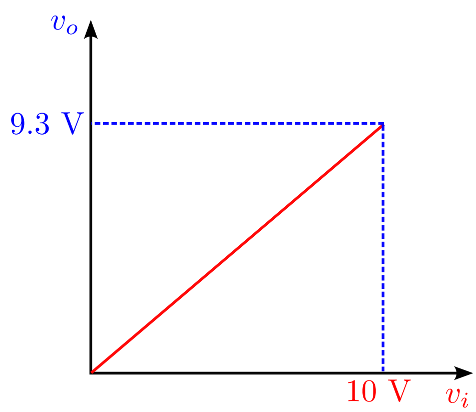

*(a)*



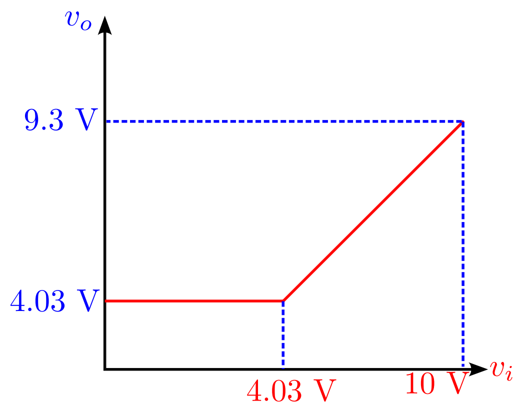

*(b)*




*(c)*




*(d)*



Solution:

The correct option is (b).

If the diode is not conducting the output voltage,

$$v_o = 10 - i \times 10 \times 10^3$$

When the diode is off, the current,

$$i = \frac{20}{30}\ mA$$

Thus, when the diode is off the output voltage is

$$v_o = 10 - \frac{2}{3} \times 10 = 3.33\ V$$

The diode will start conducting only when

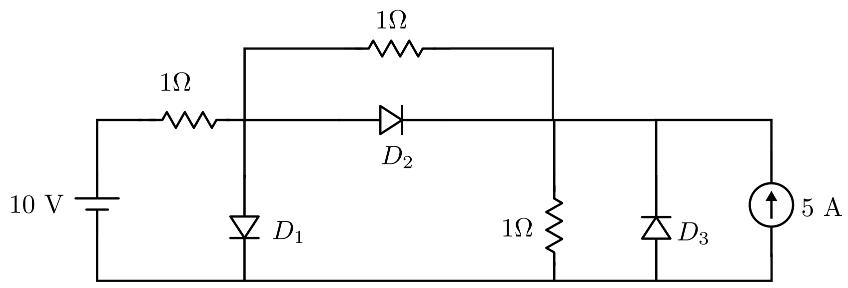
$$v_i \geq 3.33 + \ v_d, \quad i.e.\ v_i \geq 4.03\ V$$

Once the diode starts conducting

$$v_o = v_i - v_d = v_i - 0.7$$

*Question 2:*

*What are the states of the three ideal diodes of the circuit shown in the figure?*

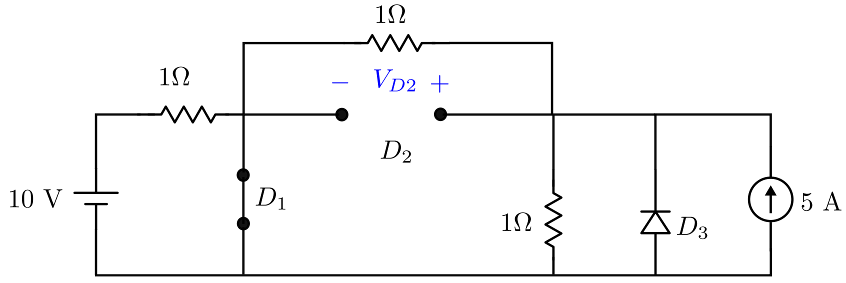



(a) $D_1$ −OFF, $D_2$ − ON, $D_3$ − OFF
(b) $D_1$ −ON, $D_2$ − OFF, $D_3$ − OFF
(c) $D_1$ −ON, $D_2$ − OFF, $D_3$ − ON
(d) $D_1$ −OFF, $D_2$ − ON, $D_3$ − ON

Solution: The correct option is (b)

Let us assume that $D_1$ is ON.

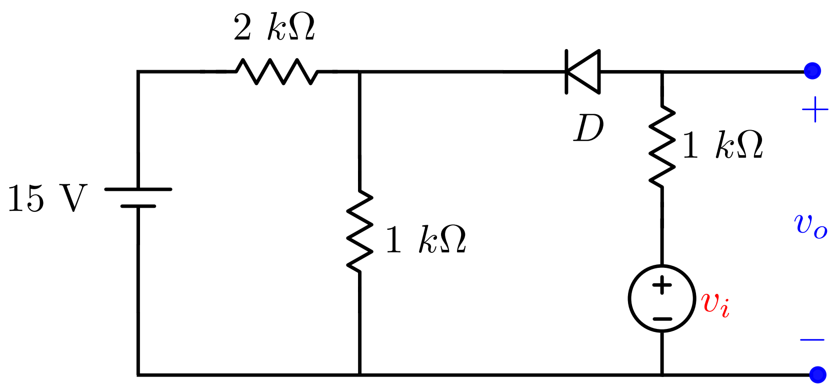
In such a case $D_2$ will be reverse biased and hence will be OFF. Thus, $V_{D2}$, will have a polarity as shown in the figure below.




Such polarity of $V_{D2}$ will reverse bias the diode $D_3$ and hence $D_3$ will be OFF. So all our assumptions were correct.

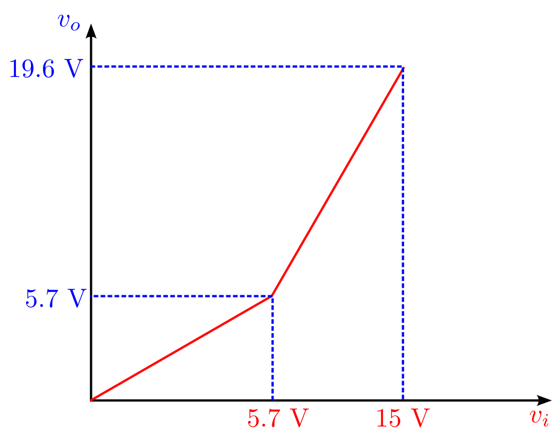
*Question 3:*

*For the circuit shown below the forward voltage drop ($v_d$) is 0.7 V.*

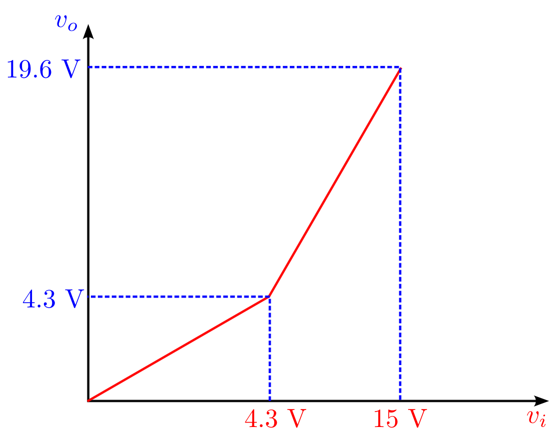



*Which of the $v_o$ versus $v_i$ plots best describe the transfer characteristics of the circuit.*

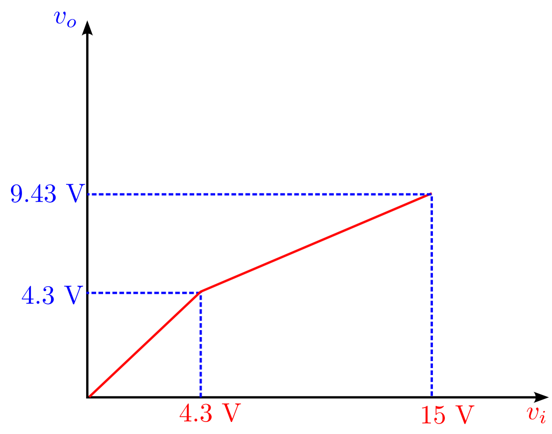
*(a)*



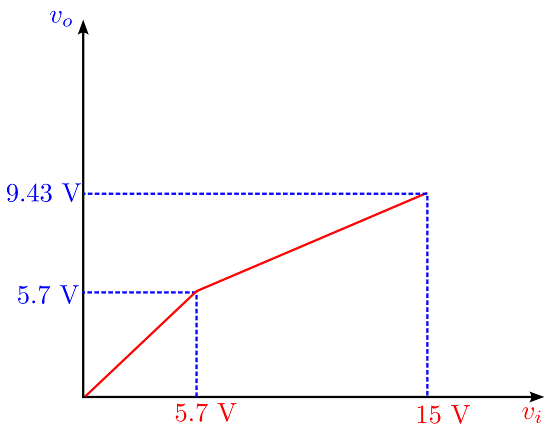

*(b)*




*(c)*



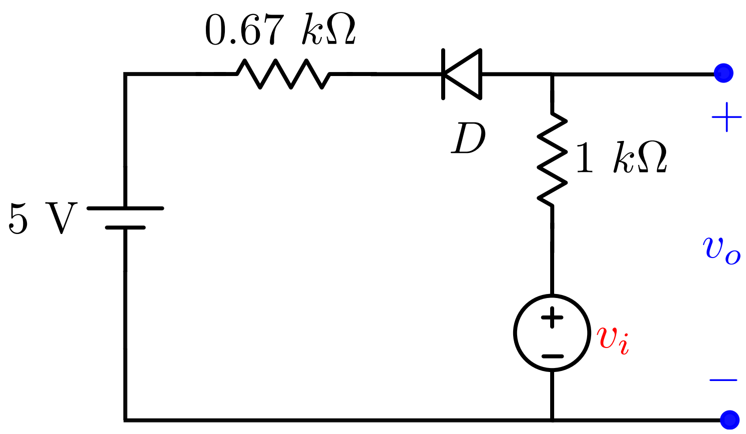

*(d)*



Solution:

The correct option is (d)

By using Thevenin's theorem the circuit can be redrawn as:




From the circuit we can conclude that the diode, $D$, will conduct only when

$$v_i > 5.7\ V$$

Thus, for $v_i\ < 5.7\ V$, the input output relation is given as

$$v_i = v_o$$

When $v_i > 5.7\ V$, the diode, $D$, will start conducting and the input output relation is given as

$$v_o = v_i - \frac{v_i - 0.7 - 5}{1.67} = 0.4\ v_i + 3.413$$

*Question 4: Numerical type*

*The forward characteristics of a power diode is given as*

$$v_D = 0.79 + 0.02\, i_D$$

*Determine the average power loss (in Watts) for a constant current of 100 A for (2/3) of a cycle.*

Solution: Answer range (185.9-186)

The average value of the diode current is

$$i_{D,avg} = 100 \times \frac{2}{3}$$

The rms value of the diode current is

$$i_{D,rms} = 100 \times \sqrt{\frac{2}{3}}$$

The average power loss in the diode is thus given by

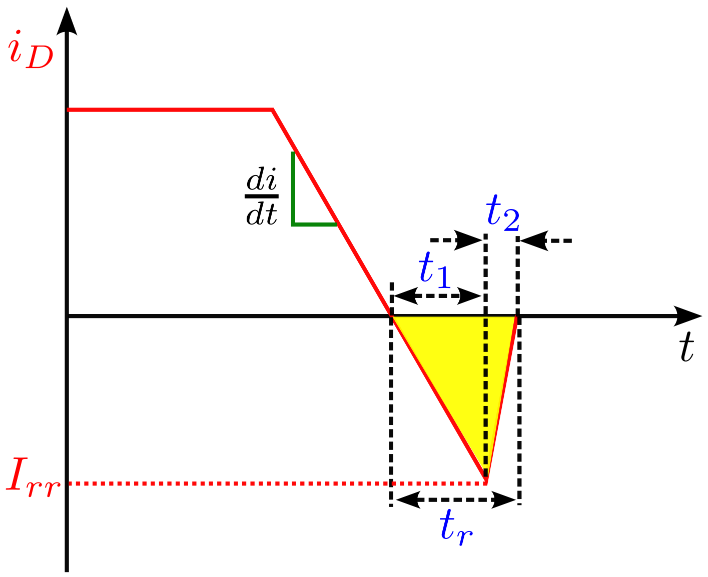
$$P_{loss} = i_{D,avg} \times 0.79 + i_{D,rms}^2 \times 0.02 = 186\, W$$

*Question 5:*

*A **fast-recovery** power diode is in the forward conduction mode and is turning off. The reverse recovery time of the diode is $t_r$ and the rate of fall of diode current is $\frac{di}{dt}$. What is the stored charge in the PN junction of the power diode?*

(a) $\frac{di}{dt} t_r$
(b) $\frac{1}{2}\frac{di}{dt} t_r$
(c) $\frac{1}{2}\frac{di}{dt} {t_r}^2$
(d) $\frac{1}{4}\frac{di}{dt} {t_r}^2$

Solution: Correct answer is (c)




Given that:

For a fast recovery diode $t_r \approx t_1$

Peak reverse recovery current can be approximated as $= \frac{di}{dt} t_r$

Stored charge =Area of the triangle shaded with yellow color$= \frac{1}{2} I_{rr}\, t_r = \frac{1}{2} \frac{di}{dt} t_r^2$

*Question 6: Numerical type*

*A power electronic switch is rated to carry full load current with an allowable case temperature of $100^{o}C$ for maximum allowable junction temperature of $125^{o}C$ and thermal resistance between case and ambience is $0.5^{o}C/W$. Find the sink temperature (in ℃) for an ambient temperature of $40^{O}C$. Take thermal resistance between sink and ambient as $0.4^{o}C/W$.*

Solution: Answer range (87-90)

Power that has to be dissipated in the ambience $= \frac{T_{Case} - T_{ambience}}{\Theta_{case-ambience}} = \frac{100-40}{0.5}\ Watts = 120\ Watts$

We want this power to be dissipated in the ambience and we need to find the temperature of the sink which will allow this power to be dissipated in the ambience.

Therefore,

$$120 = \frac{T_{sink} - T_{ambience}}{\Theta_{sink-ambience}}$$

Therefore,

$$T_{sink} = 120 \times \Theta_{sink-ambience} + T_{ambience}$$

$$= 120 \times 0.4 + 40 = 88^{o}C \text{ (Answer)}$$

Where,

$T_{Case} = Temperature\ of\ Case$

$T_{sink} = Temperature\ of\ heat\ sink$

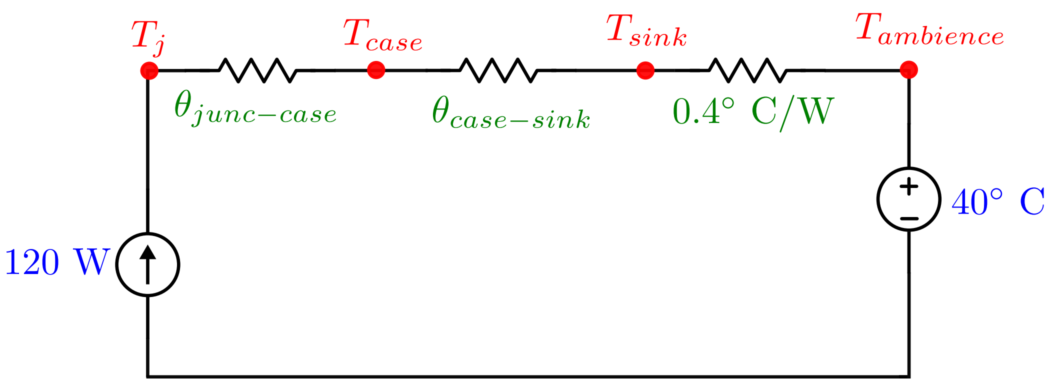
$T_{ambience} = Ambient\ temperature$

$T_j = Junction\ temperature$

$\Theta_{sink-ambience} = sink\ to\ ambience\ thermal\ resistance$

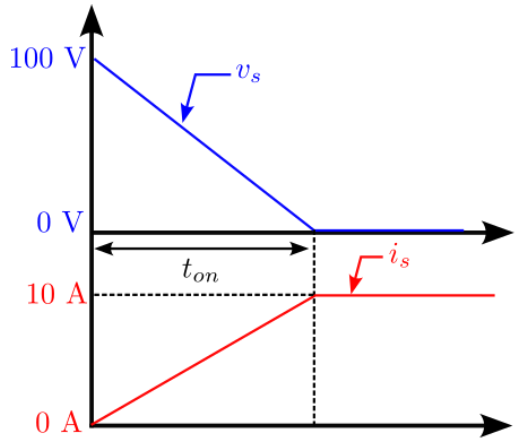
$\Theta_{case-ambience} = case\ to\ ambience\ thermal\ resistance$

$\Theta_{junc-case} = Junction\ to\ case\ thermal\ resistance$



*Question 7:*

*The following figure shows on-transition of a switch. Find the peak instantaneous power loss in watts. Consider the turn on transition time ($t_{on}$) = 5μsec and the total switching time period to be 50μsec.*




*(a) 167 Watts*
*(b) 500 Watts*
*(c) 334 Watts*
*(d) 250 Watts*

Solution: Correct option is (d).

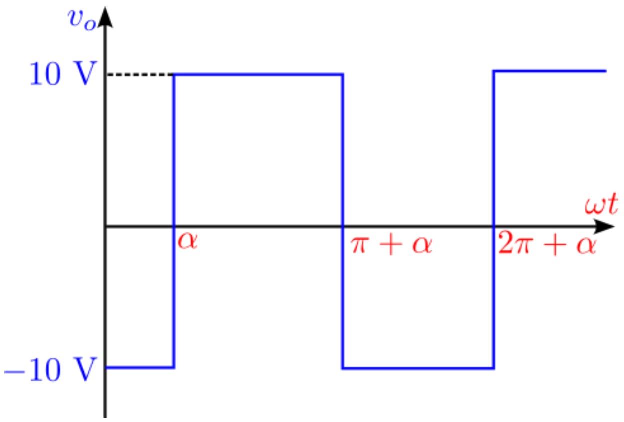
The peak instantaneous power would occur at $\frac{t_{on}}{2}$.

Therefore, the peak power is given by

$$P_{max} = v_s\left(t = \frac{t_{on}}{2}\right) \times i_s\left(t = \frac{t_{on}}{2}\right) = \frac{100}{2} \times \frac{10}{2} = 250\ W$$

*Question 8:*

*The output voltage of a power electronic converter is shown below. The rms value of the fundamental component will be.*




(a) $\frac{40}{\pi}\ V$

(b) $\frac{4}{\pi}\ V$

(c) 10 V

(d) 9 V

Solution:

The correct option is (d).

The fundamental component of the square wave voltage is given by

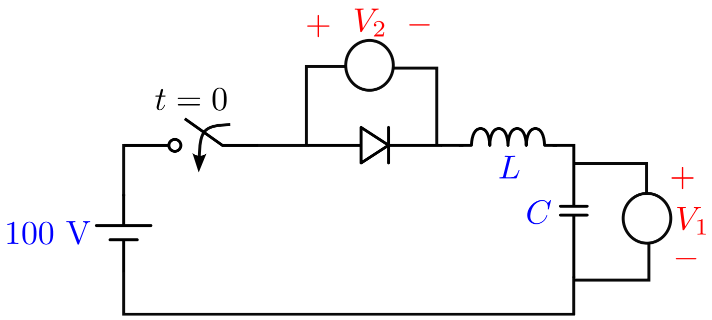
$$V_{o,1} = \frac{40}{\pi}\sin(\omega t - \alpha)$$

Thus, the rms value of the fundamental component will be

$$V_{o,1,rms} = \frac{40}{\pi \times \sqrt{2}} = 9\ V$$

*Question 9:*

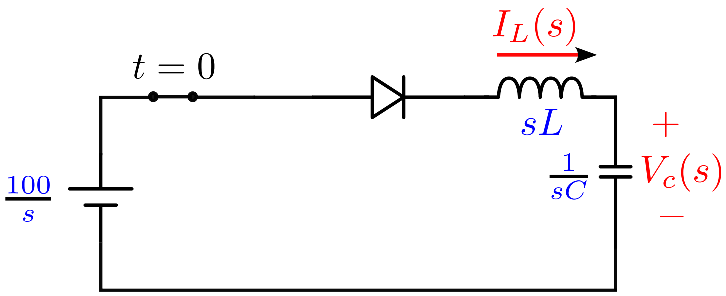
*In the circuit shown in the figure $V_1$, and $V_2$ are reading of zero centre PMMC (Permanent Magnet Moving Coil) voltmeters. The circuit is initially relaxed. The switch is closed at t=0. In steady state what will be the value of $V_1$ ? (Assume the diode to be ideal)*




- *(a) 100 V*
- *(b) -100 V*
- *(c) 0 V*
- *(d) 200 V*

Solution: Correct answer is (d)

At t = 0, when the switch is closed, the circuit can be redrawn to write the circuit equation in Laplace domain as shown in the figure below:




The KVL equation is s-domain can be written as:

$$\frac{100}{s} = (sL + \frac{1}{sC})I_L(s)$$

As, the circuit was initial conditions are zero i.e. $i_L(t=0) = 0\ A$ and $v_c(t=0) = 0\ V$ we can write the transfer function of the inductor current as

$$I_L(s) = 100\sqrt{\frac{C}{L}}\left(\frac{\frac{1}{\sqrt{LC}}}{s^2 + \frac{1}{LC}}\right)$$

Now, taking inverse Laplace transform we get

$$i_L(t) = 100\sqrt{\frac{C}{L}}\sin\left(\frac{t}{\sqrt{LC}}\right) = 100\sqrt{\frac{C}{L}}\sin(\omega_o t)$$

The equation for capacitor voltage , $v_c(t)$ will then be given as

$$v_c(t) = \frac{1}{C}\int_0^t i_L(t)\,dt = 100(1 - \cos(\omega_o t))$$

Now, when $\omega_o t > \pi$

$$i_L(t) < 0$$

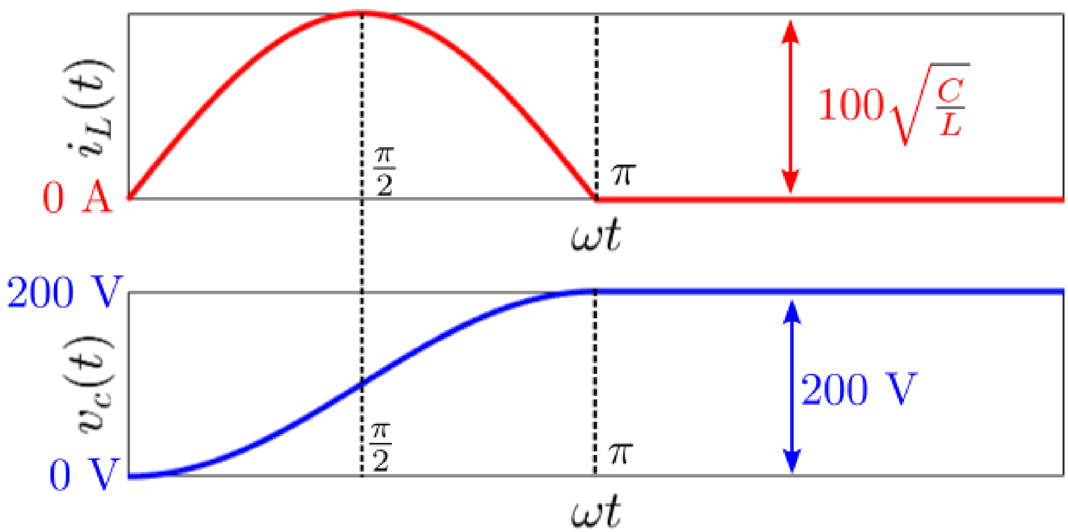
However, the diode will not allow $i_L(t)$ to go below 0 A. Hence the diode gets turned off at $\omega_o t = \pi$ and remains off.

The capacitor voltage at $\omega_o t = \pi$ is given by

$$100(1 - \cos\pi) = 200\,V$$

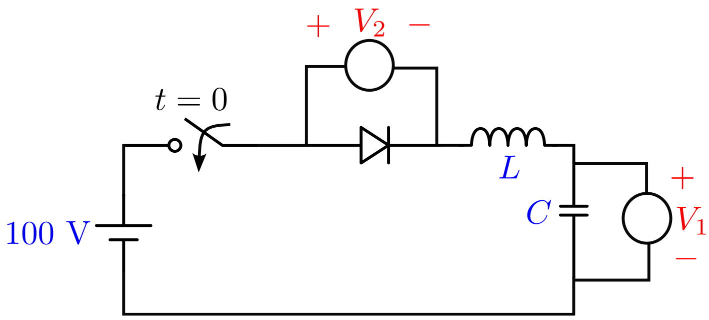
The capacitor voltage stays put at 200 V for $\omega_o t > \pi$. Thus the voltmeter reading $V_1 = 200\,V$.

The waveforms of the inductor current or diode current, $i_L(t)$, and the capacitor voltage, $v_c(t)$, is shown in the figure below.



*Question 10:*

*In continuation to the previous problem, the circuit shown in the figure $V_1$, and $V_2$ are reading of zero centre PMMC voltmeters. The circuit is initially relaxed. The switch is closed at t=0. In steady state what will be the value of $V_2$ ?*




*(a) 100 V*
*(b) -100 V*
*(c) 0 V*
*(d) 200 V*

Solution: Correct option is (b)

At steady state the voltage across the inductor, $L$, = 0V as no current flows through it.

The voltage across the capacitor, $V_1 = 200\ V$.

Therefore, at steady state the voltage across the diode, $V_2$, is given by

$$V_2 = 100 - V_1 = 100 - 200 = -100\ V$$

The waveforms of the voltage across the capacitor, $v_c(t)$, the current through the inductor, $i_L(t)$, and the voltage across the diode, $v_d(t)$ is shown in the figure below.