Q2 (a) Evaluate $\lim_{x\to 0} \frac{\log \sin 2x}{\log \sin x}$

Answer

$$\lim_{x\to 0} \frac{\log \sin 2x}{\log \sin x}$$

$$=> \lim_{x\to 0}\left(\frac{\frac{1}{\sin 2x}.2COS\,2X}{\frac{1}{\sin x}.\cos x}\right)$$

$$=> \lim_{x\to 0}\left(\frac{\sin x}{\sin 2x}.\frac{2\cos 2x}{\cos x}\right)$$

$$=> \lim_{x\to 0}\left(\frac{\sin x}{2\sin x cox}.\frac{2\cos 2x}{\cos x}\right)$$

$$=> \lim_{x\to 0}\left(\frac{\cos 2x}{\cos^2 x}\right) = \frac{\cos 0}{\cos^2 0} = \frac{1}{1} = 1$$

Q2 (b) Expand $\cos x$ **in powers of** $\left(x - \pi/4\right)$ **upto 4 terms. (Using Taylor's Expansion).**

Answer

We have

$$f(x) = f\{(x - \pi/4) + \pi/4\} = f(\pi/4) + (x - \pi/4) f^{i}(\pi/4)$$
$$+ (1/2)(x - \pi/4)^2 f^{ii}(\pi/4) + ------$$
$$=> now\ f(x) = \cos x,\ f^{i}(x) = -\sin x.$$
$$=> f^{ii}(x) = -\cos x,\ f^{iii}(x) = \sin x........$$
$$=> .:.\ f(\pi/4) = \cos \pi/4 = 1/\sqrt{2},\ f^{i}(\pi/4) = -\sin(\pi/4) = -1/\sqrt{2}$$
$$=> f^{ii}(\pi/4) = -\cos \pi/4 = -1/\sqrt{2},\ f^{iii}(\pi/4) = \sin \pi/4 = 1/\sqrt{2},....$$

Substituting in (1), we get

$$\cos x = 1/\sqrt{2} + (x - \pi/4).(-1/\sqrt{2}) + 1/2!(x - \pi/4)^3(1/\sqrt{2})........$$

$$= 1/\sqrt{2}\{1 - (x - \pi/4) - ((x - \pi/4)^2/2!) + (x - \pi/4)^3/3!\ .....\}$$

Q3 (a) Evaluate $\int_0^{2a} x^2 \sqrt{2ax - x^2}\,dx$**.**

Answer

$$let\ \mathrm{I} = \int_0^{2a} x^2 \sqrt{2ax - x^2}\,dx$$

$$=> \int_0^{2a} x^2 . x^{1/2} \sqrt{2a - x}\ dx$$

$$=> \int_0^{2a} x^{5/2} \sqrt{2a - x}\ dx$$

$$\text{let x} = 2\text{a} \sin^2 Q, .:.dx = 4a\ SinQ\ CosQ\ dQ$$

$$when x = 0, Q = 0; \&\ \text{when x} = 2\text{a}, \text{Q} = \pi/2$$

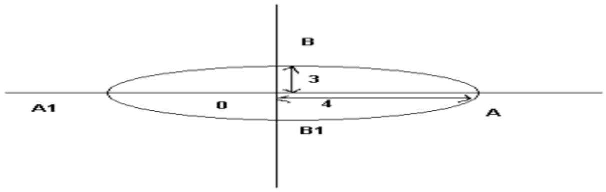
$$.:.I = \int_0^{\pi/2} (2a)^{5/2} \sin^5 Q \sqrt{2a - 2a\sin^2 Q}.4a \sin Q \cos Q$$

$$= 32x^4 \int_0^{\pi/2} \sin^6 Q \cos^2 Q\, dQ$$

$$= 32x^4 \left(\frac{5*3*1*1}{8*6*4*2} \right) * \pi/2 = \frac{5\pi a^4}{8}$$

Q3 (b) Find the volume generated by revolving the ellipse $\frac{x^2}{16} + \frac{y^2}{9} = 1$ **about the x-axis.**

Answer



$$\frac{x^2}{16}+\frac{y^2}{9}=1$$
$$=> .:. \frac{y^2}{9}=1-\frac{x^2}{16}$$
$$=> \frac{16-x^2}{16}$$
$$=> y^2=\frac{9}{16}(16-x^2)$$
$$.:.\text{Requird volume}=2\pi\int_0^4 y^2dx$$
$$=2\pi\int_0^4\frac{9}{16}(16-x^2)dx$$
$$=\frac{9\pi}{8}[16x-\frac{x^3}{3})_0{}^4$$
$$=\frac{9\pi}{8}(64-\frac{64}{3})$$
$$=\frac{9\pi}{8}(\frac{192-64}{3})=\frac{9\pi}{8}=\frac{128}{3}=48\pi$$

Q4 (a) If $x+iy=\sqrt{\frac{a+ib}{c+id}}$**, prove that** $\left(x^2+y^2\right)^2=\frac{a^2+b^2}{c^2+d^2}$**.**

Answer

$$\text{we have } x+iy=\sqrt{\frac{a+ib}{c+id}}\text{.............................(1)}$$
taking congugate
$$=> x+iy=\sqrt{\frac{a-ib}{c-id}}\text{..(2)}$$
multiplying (i) & (ii) we get
$$(x+iy)(x-iy)=\sqrt{\frac{a-ib}{c-id}}*\sqrt{\frac{a-ib}{c-id}}=\sqrt{\frac{(a+ib)(a-ib)}{(c-id)(c+id)}}$$
$$=> \sqrt{\frac{(a^2-i^2b^2)}{(c^2-i^2d^2)}}=\sqrt{\frac{(a^2+b^2)}{(c^2+d^2)}}$$

Q4 (b) Prove that $(1+\mathrm{i})^{\mathrm{n}}+(1-\mathrm{i})^{\mathrm{n}}=2^{(\mathrm{n}/2)+1}\cos\left(\frac{\mathrm{n}\pi}{4}\right)$

Answer

$$(1+i)^n+(1-i)^n=2^{(n/2)+1}\cos\left(\frac{n\pi}{4}\right)$$

$$=> 1+i=r(\cos\phi+\sin\phi).then$$

$$=> r=\sqrt{(1^2-1^2)}=\sqrt{2}$$

$$\& \tan\mathrm{Q}=1/1=1$$

$$=> \mathrm{Q}=\frac{\pi}{4}$$

$$.:.1+i=\sqrt{2}\,(\cos\frac{\pi}{4}+i\sin\frac{\pi}{4})$$

$$=> (1+i)^n=(\sqrt{2}\,)^n((\cos\frac{\pi}{4}+i\sin\frac{\pi}{4})^n$$

$$=> (2)^{n/2}(\cos\frac{n\pi}{4}+i\sin\frac{n\pi}{4}+i\sin\frac{n\pi}{4}).........................(1)$$

let the polar form of 1 - i be r($\cos\phi$ + i $\sin\phi$).

then, $\mathrm{r}=\sqrt{1^2+(-1)^2}=\sqrt{2}$

$$\& \tan\phi=(\frac{-1}{1})=-1=\tan(-\frac{\pi}{4})$$

$$.:.1-i=\sqrt{2}\,(\cos\frac{\pi}{4}-i\sin\frac{\pi}{4})$$

$$(1-i)^n=(\sqrt{2}\,)^n(\cos(-\frac{\pi}{4})+i\sin(-\frac{\pi}{4}))^n$$

$$=(\sqrt{2}\,)^n(\cos(-\frac{x\pi}{4})+i\sin(-\frac{x\pi}{4}))$$

$$=(2)^{n/2}(\cos(\frac{x\pi}{4})-i\sin(\frac{x\pi}{4})$$

Adding 1 & 2

$$=(1+i)^n+(1-i)^n=2^{n/2}\left(\cos\frac{n\pi}{4}+i\sin\frac{n\pi}{4}+\cos\frac{n\pi}{4}-i\sin\frac{n\pi}{4}\right)$$

$$=2^{n/2}(2\cos\frac{n\pi}{4})$$

$$=2^{n/2+1}(\cos\frac{n\pi}{4})$$

Q5 (a) What is the unit vector perpendicular to each of the vectors $2\hat{i}-\hat{j}+\hat{k}$ & $3\hat{i}+4\hat{j}-\hat{k}$? Calculate the sine of the angle between these two vectors

Answer

The vector obtained by cross multiplying the givens vectors is perpendicular to each of the given vectors. When a¯=2i-j+k &b¯=3i+4j-k

= a¯* b¯

$$\begin{vmatrix} i & j & k \\ 2 & -1 & 1 \\ 3 & 4 & -1 \end{vmatrix}$$

$= = (1-4)i-(-2-3)j+(8+3)k$

$= -3i+5j+4k$

the magnitude of this vector = $\sqrt{9+25+121}=\sqrt{135}$

.:. Unit vectors ⊥to the given vectors

=+(-) $\frac{1}{\sqrt{155}}(-3i+5j+11k)$

let ϕ be the angle between vectors since the magnitude of a¯* b¯ is | a¯|| b¯| sin ϕ,we have , magnitude of (2i-j+k)*(3i+4j-k)

=|2i-j+k| |3i+4j-k| sinϕ

= $\sqrt{4+1+1}\sqrt{9+16+1}\sin\phi$

$= \sqrt{156}\sin\phi$

but the magnitutude of a¯* b¯ must be same as the magnitude of – 3i+5j +11k

.:. $= \sqrt{156}\sin\phi = \sqrt{155}$

$= \sin\phi = \sqrt{155/156}$

Q5 (b) A force is represented in magnitude and direction by the line joining the point A(1,-2,4) to the point B(5,2,3). Find its moment about the point (-2, 3, 5).

Answer

We have F¯ =AB¯
=P.V of B – P.V of ^
=(5I+2J+3k)-(i-2j+4k)
=4i+4j-k
let O be the point (-2,3,5).then
r¯= OA¯=P.V of A-P.Vof 0
=3i-5j-k
then

m¯= r¯* F¯= $\begin{vmatrix} i & j & k \\ 3 & -5 & -1 \\ 4 & 4 & -1 \end{vmatrix}$

= (5+4) I-(-3+4j + (12+20)k
=9i-j+32k

Q6 (a) Solve $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = e^{3x}$

Answer

The given e.g $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = e^{3x}$
Can be usettern as:
$(D^2 - 5D + 6) = e^{3x}$
The A.E of the above equation is $= (m^2 - 5m + 6) = 0$
Which gives m= 2, 3
Hence the complemen bary function is:
C.F=G $e^{2x} + C_2\, e^{3x}$ where, C_1, C_2 are Arbibrary constants

Now P.I

⇨ $1/(D^2 - 5D + 6)e^{3x}$

⇨ (1/D-2)- (1/D-3) e^{3x}

⇨ (1/D-3) e^{3x} -(1/D-2) e^{3x}

$=> e^{3x}\int e^{-3x}e^{3x}dx - e^{2x}\int e^{-2x}e^{3x}dx$

⇨ $=> e^{3x}\int dx - e^{2x}\int e^{x}dx$

$=> xe^{3x} - e^{2x}.e^{x}$

$=> xe^{3x} - e^{3x} = (x-1)e^{3x}$

⇨ Hence the genral solution is

$=> y = C.F + P.I = Ge^{2x} + C_2e^{3x} + e^{3x}(X-1)$

$=> Ge^{2x} + (C_2 - 1)e^{3x} + xe^{3x}$

$=> Ge^{2x} + C_3e^{3x} + xe^{3x}, Where\, C_3 = C_2 - 1$

new constant

Q6 (b) Solve $\frac{d^2y}{dx^2} - \frac{dy}{dx} - 2y = 2x^2$ **, given that** $y(0) = 0$ **and** $y'(0) = 0$ **.**

Answer

The given differential equation is symbolic form will be

$$(D^2 - D - 2) = 2x^2$$

The auxiliary equation is $m^2 - m - 2 = 0$ or (m-2) (m+1) =0

Which gives m=2,-1:. C.F= $C_1 e^{2x} + C_2 e^{-x}$

Now P.I

$$=> \frac{1}{D^2 - D - 2} 2x^2$$

$$=> 2\frac{1}{-2(1 + \frac{D}{2} - \frac{D^2}{2})} x^2$$

$$=> -1(1 + \frac{D}{2} - \frac{D^2}{2}))^{-1} x^2$$

$$=> -1[1 - \frac{D}{2} - \frac{D^2}{2}) + (\frac{D}{2} - \frac{D^2}{2})^2 ----]x^2$$

$$=> [1 - \frac{D}{2} - \frac{D^2}{2} + \frac{D^2}{4} + ------]x^2$$

$$=> [1 - \frac{D}{2} - \frac{3}{4} D^2 + ------]x^2$$

$$=> -[x^2 - \frac{1}{2} Dx^2 + \frac{3}{4} D^2 x^2 + ----]$$

$$=> -[x^2 - \frac{1}{2} 2x + \frac{3}{4}]$$

$$=> -[x^2 - x + \frac{3}{2}]$$

=> *So* the genral solution is given by

$$=> \mathrm{y} = \mathrm{c}_1\, \mathrm{e}^{2x} + c_2 e^{-x} - x^2 + x - 3/2 ....(1)$$

Differentiating this w.r.t x, we get

$$\frac{dy}{dx} = 2C_1 e^{2x} - C_2 e^{-x} - 2x + 1 ....(2)$$

it is given that y = 0 and $\frac{dy}{dx} = 0$ at x = 0.

=> so, on putting x = 0 in (i)and(ii), we get.

$$0 = C_1 - C_2 - \frac{3}{2}$$

$$\& \; 0 = 2C_1 - C_2 + 1$$

*S*olving these two equations : we get

$$C_1 = \frac{1}{6}, C_2 = \frac{4}{3}$$

putting values of $C_1 \& C_2$ in (i), we get

$$y = 1/6e^{2x} + 4/3e^{-x} - x^2 + x - 3/2.$$

Q7 (a) Obtain a Fourier series representation for f(x) where

$$f(x) = \left(\frac{\pi - x}{2}\right)^2, 0 < x < 2\pi.$$

Answer

Let the fourier series of f(x) be

$a_{0/2+} \sum_{n=1}^{\infty}$ (a_n cosnx +b_n sinnx)

where a0$_{=1/}$ $\pi \int_0^{2\pi}$ f(x)dx, $a_{n=1/}$ $\pi \int_0^{2\pi}$ f(x)cosnxdx

$b_{n=1/}$ $\pi \int_0^{2\pi}$ f(x)sinnxdx.

Now , $a_{0\,=\,1/}$ $\pi \int_0^{2\pi}$ f(x)dx =$_{1/}$ $\pi \int_0^{2\pi} \left(\frac{\pi - x}{2}\right)^2$ dx

$=_{1/}\ 4\pi \int_0^{2\pi} (\pi - x)^2$ dx.

$=_{1/}\ 4\pi \int_0^{2\pi} \left(\frac{(\pi - x)3}{-3}\right)^{2\pi}{}_0$ dx.

$$=> \frac{-1}{2\pi}\left((\pi-2\pi)^3-(\pi-0)^3\right)$$

$$=> \frac{-1}{2\pi}\left((-\pi)^3-(\pi)^3\right)$$

$$=> \frac{2\pi^3}{2\pi}=\frac{\pi^2}{6}$$

$$=> a_n=\frac{1}{\pi}\int_0^{2\pi} f(x)\cos nxdx.$$

$$=> \frac{1}{\pi}\int_0^{2\pi}\left(\frac{\pi-x}{2}\right)^2 \cos nxdx.$$

$$=> \frac{1}{\pi}\left[\left(\left(\frac{\pi-x}{2}\right)^2\frac{\sin 2x\pi}{x}\right)^{2\pi}{}_0-\int_0^{2\pi}-\frac{1}{4}2(\pi-x)\frac{\sin x}{x}dx\right]$$

$$=> \frac{1}{\pi}\left[\left(\left(\frac{\pi-2x}{2}\right)^2\frac{\sin 2x\pi}{x}-\left(\frac{\pi-0}{2}\right)^2\left(\frac{\sin 0}{x}\right)_0+\frac{1}{2\pi}\int_0^{2\pi}(\pi-x)\sin nxdx\right)\right]$$

$$=> \frac{1}{2n\pi}\int_0^{2\pi}(\pi-x)\sin nxdx$$

$$=> \frac{1}{2n\pi}\left[(\pi-x)\left(\frac{-\cos nx}{x}\right)^{2\pi}-\int_0^{2\pi}(1)\frac{\cos nx}{x}dx\right]$$

$$=> \frac{1}{2n\pi}\left[-((\pi-2x)\frac{\cos 2n\pi}{x}-(\pi-0)\frac{\cos 0}{x})1/x\left(\frac{\sin nx}{x}\right)^{2\pi}{}_0\right]$$

$$=> \frac{1}{2n\pi}\left[\frac{\pi}{x}\cos 2n\pi+\frac{\pi}{x}\right]-\frac{1}{2n\pi(x)^2}(\sin 2x\pi-\sin 0)$$

$$=> \frac{1}{2n\pi}\left[\frac{\pi}{x}(-1)^{2x}+\frac{\pi}{x}\right]$$

$$=> \frac{1}{2n\pi}(\frac{2\pi}{x})=\frac{1}{(x)^2}$$

$$=> \frac{1}{\pi}\left[\left(\left(\frac{-2\pi}{x}\right)^2\frac{\cos 2n\pi}{x}-\left(\frac{\pi-0}{2}\right)^2\frac{\cos 0}{x}\right)-2/4x\int_0^{2\pi}(\pi-x)\cos nxdx\right]$$

$$=> -\frac{1}{2n\pi}\left[-(\frac{\pi^2}{4x}-\frac{\pi^2}{4x})-\frac{1}{2x}\int_0^{2\pi}(1)\frac{\sin nx}{x}dx\right]$$

$$=> -\frac{1}{\pi}\left[-((\frac{\pi-2\pi}{4x})\sin 2x\pi-(\frac{\pi-0}{x})\sin 0)+1/x\left(\frac{-\cos nx}{x}\right)^{2\pi}{}_0\right]$$

$$=> \frac{1}{2n\pi}\left[\frac{1}{x^2}(\cos 2n\pi-\cos 0)\right]=0$$

=> Substituting the values of a_0, a_n and b_n in (i), we obtaine the series

$$= \frac{\pi^2}{12} + \left[\frac{1}{1^2}\cos x + \frac{1}{2^2}\cos 2x + \frac{1}{3^2}\cos 3x + ... \right]$$

=

Q7 (b) Find the Fourier sine series which represents $f(x) = \pi - x$ in the interval $(0, \pi)$

Answer

A fauries series consisting of since terms alone is obtained only for an add function. Hence me extended the function f(x) on the internal $[-\pi, \pi]$ so that it becomes an add function for this me define:

$$F(x) = \begin{cases} f(x), \; for 0 < x < \pi \\ -f(-x), \; for \text{ -}\pi < x < 0 \end{cases}$$

$$= \begin{cases} \pi - x, \; for \; 0 < x < \pi \\ -(\pi + x), \; for \text{ -}\pi < x < 0 \end{cases}$$

Now f(x) is an odd function on $(-\pi, \pi)$,therefore its fourier series is purely a sine series given by

$$= \sum_{n=1}^{\infty} \text{ bn sinnx}......................................(i)$$

where $b_n = 2/\pi \int_0^{\pi}$ f(x)sinnx dx $= 2/\pi \int_0^{\pi} (\pi - x)$ sinnxdx

$= 2/\pi$ [- $(\pi - x)$ cosnx/x-sinnx/x] π 0

$= 2/\pi$ (π /x)=2/x

substituting the value of b_n in (i) we get

$$== \sum_{n=1}^{\infty} \text{ 2/x sinnx.}$$

As the fouries series for f(x).since f(x) is continous in (0, π).Consegnently

$$=> \pi - x = \sum_{n=1}^{\infty} 2/n \sin nx$$

$$=> 2\left[\frac{\sin x}{1} + \frac{\sin 2x}{2} + \frac{\sin 3x}{3} + ... \right]$$

Q8 (a) Find the Laplace transform of $t^2 \cos at$

Answer

$$=> \text{since } L\{Cosat\} = \frac{s}{s^2+d^2}$$

$$=> \therefore L\{t^2 Cosat\} = (-1)^2 \frac{d^2}{ds^2}\left(\frac{s}{s^2+a^2}\right)$$

$$=> \frac{d}{ds}\left(\frac{d}{ds}\left(\frac{s}{s^2+a^2}\right)\right)$$

$$= \frac{d}{ds}\left(\frac{s^2+a^2-s(25)}{(s^2+a^2)^2}\right)$$

$$=> \frac{d}{ds}\left(\frac{a^2-s^2}{(s^2+a^2)^2}\right)$$

$$=> -25(s^2+a^2)^{-2} + (s^2+a^2)(-2)(s^2+a^2)^{-3}(25)$$

$$=> \frac{-25}{(s^2+a^2)^2} - \frac{45(a^2-s^2)}{(s^2+a^2)^3}$$

$$=> \frac{-25(s^2+a^2)-45(a^2-s^2)}{(s^2+a^2)^3}$$

$$=> \frac{-25s^3-25a^2-45a^2+4s^3}{(s^2+a^2)^3}$$

$$=>=> \frac{-25s^3+a^2}{(s^2+a^2)^3} ==> \frac{25(s^2+3a^2)}{(s^2+a^2)^3}$$

Q8 (b) Find Laplace transform of $\frac{1-e^{2t}}{t}$

Answer

$$=> we \text{ have } L\{1-e^{2t}\} = \frac{1}{S} - \frac{1}{S-2}$$

$$=> \&lt \text{ t} \to 0 \frac{1-e^{2t}}{t} = -2lt \text{ t} \to 0 \frac{e^{2t}-1}{2t} = -2\times 1 = -2exist$$

$$=> \therefore L\left\{\frac{1-e^{2t}}{t}\right\} = \int_5^{\infty} \left(\frac{1}{S} - \frac{1}{S-2}\right) ds$$

$$=> [\log 5 - \log(s-2)]_5^{\infty}$$

$$=> \left[\log\left(\frac{1}{S-2}\right)\right]_5^{\infty}$$

$$=> lt \text{ s} \to \infty \log\left(\frac{1}{S-2}\right) - \log\left(\frac{1}{S-2}\right)$$

$$=> \log\left(\frac{S-2}{S}\right) - lt \text{ s} \to \infty \log\left(\frac{S-2}{S}\right)$$

$$=> \log\left(\frac{S-2}{S}\right) - lt \text{ s} \to \infty \log\left(1-\frac{2}{S}\right)$$

$$=> \log\left(\frac{S-2}{S}\right) - \log 1$$

$$=> \log\left(\frac{S-2}{S}\right)$$

Q9 (a) Find $L^{-1}\left\{\dfrac{3s+9}{(s^2+2s+10)}\right\}$

Answer

$$=> L^{-1}\left\{\frac{3s+9}{(s^2+2s+10)}\right\} = L^{-1}\left\{\frac{3s+9}{(s\ \ +1)^2+(3)^2}\right\}$$

$$=> L^{-1}\left\{\frac{3(s+1)}{(s\ \ +1)^2+(3)^2}\right\} + L^{-1}\left\{\frac{6}{(s\ \ +1)^2+(3)^2}\right\}$$

$$=> 3L^{-1}\left\{\frac{s+1}{(s\ \ +1)^2+(3)^2}\right\} + 6L^{-1}\left\{\frac{1}{(s\ \ +1)^2+(3)^2}\right\}$$

$$=> 3e^{-t}L^{-1}\left\{\frac{S}{(s)^2+(3)^2}\right\} + 6e^{-t}L^{-1}\left\{\frac{1}{(s)^2+(3)^2}\right\}$$

$$=> 3e^{-t}\cos 3t + 6e^{-t}\left(\frac{\sin 3t}{3}\right)$$

$$=> 3e^{-t}\cos 3t + 2e^{-t}\sin 3t$$

$$=> e^{-t}(3\cos 3t + 2\sin 3t)$$

Q9 (b) Use convolution theorem to find $L^{-1}\left\{\dfrac{1}{(s^2-s-2}\right\}$

Answer we have,

$$L^{-1}\left\{\frac{1}{(s^2-s-2}\right\} = L^{-1}\left\{\frac{1}{(s-2)(s+2)}\right\}$$

$$\& \ L^{-1}\left\{\frac{1}{s-2}\right\} = e^{2b},\ L^{-1}\left\{\frac{1}{(s+2)}\right\} = e^{-t}$$

$$\therefore L^{-1}\left\{\frac{1}{(s-2)(s+2)}\right\} = \int_0^t e^{-4}e^{2(t-4)}du$$

$$= e^{2t}\int_0^t e^{-34}du$$

$$= e^{2t}\left[\frac{e^{-3u}}{-3}\right]_0^t$$

$$= \frac{-1}{3}e^{2t}(e^{-3t}-e^0)$$

$$= \frac{-1}{3}(e^{2t-3t}-e^{2t})$$

$$= \frac{-1}{3}(e^{-t}-e^{2t}) = \frac{1}{3}(e^{2t}-e^t)$$

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