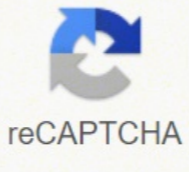




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Let y be the number of bacteria at any instant t .
 It is given that the rate of growth of the bacteria is proportional to the number present.
 $\therefore \frac{dy}{dt} \propto y$
 $\Rightarrow \frac{dy}{dt} = ky$ (where k is a constant)
 $\Rightarrow \frac{dy}{y} = kdt$
 Integrating both sides, we get:
 $\int \frac{dy}{y} = k \int dt$
 $\Rightarrow \log y = kt + C$... (1)

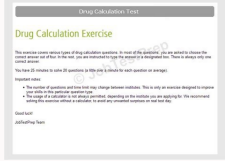
Multiplying equation (1) with 2 and then subtracting it from equation (2), we get:
 $y'' - 2y' = e^{2x}2a + 2bx + b - e^{2x}2a + 2bx \Rightarrow y'' - 2y' = be^{2x}$... (3)
 Differentiating both sides with respect to x , we get:
 $y'' - 2y' = 2be^{2x}$... (4)
 Dividing equation (4) by equation (3), we get:
 $\frac{y'' - 2y'}{y' - 2y} = 2$
 $\Rightarrow y'' - 2y' = 2y' - 4y$
 $\Rightarrow y'' - 4y' + 4y = 0$
 This is the required differential equation of the given curve.

Question 5:
 $y = e^x (a \cos x + b \sin x)$

Answer:
 $y = e^x (a \cos x + b \sin x)$... (1)
 Differentiating both sides with respect to x , we get:
 $y' = e^x (a \cos x + b \sin x) + e^x (-a \sin x + b \cos x)$
 $\Rightarrow y' = e^x [(a+b) \cos x - (a-b) \sin x]$... (2)
 Again, differentiating with respect to x , we get:
 $y'' = e^x [(a+b) \cos x - (a-b) \sin x] + e^x [-(a+b) \sin x - (a-b) \cos x]$
 $y'' = e^x [2b \cos x - 2a \sin x]$
 $y'' = 2e^x (b \cos x - a \sin x)$
 $\Rightarrow \frac{y''}{2} = e^x (b \cos x - a \sin x)$... (3)
 Adding equations (1) and (3), we get:

III.
 a) We must show $V \cup \{0\}$ is closed under addition and scalar multiplication. Recall that $V \cup \{0\}$ is precisely the set of vectors $v \in \mathbb{R}^p$ with $Av = \lambda v$.
Scalar Multiplication: Let $v \in V \cup \{0\}$, $c \in \mathbb{R}$. Then we have
 $A(cv) = c(Av) = c \cdot \lambda v = \lambda \cdot (cv)$.
 Thus $cv \in V \cup \{0\}$.
Addition: Let $v_1, v_2 \in V \cup \{0\}$. Then we have
 $A(v_1 + v_2) = Av_1 + Av_2 = \lambda v_1 + \lambda v_2 = \lambda(v_1 + v_2)$.
 Thus $v_1 + v_2 \in V \cup \{0\}$.
 b) Recall that the eigenvalues of A are precisely the roots of the "characteristic polynomial of A ",
 $\det(A - xI_p)$,

c) consider function:
 $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$
 The gradient is:
 $g(x) = \begin{pmatrix} -400x_1(x_2 - x_1^2) - 2(1 - x_1) \\ 200(x_2 - x_1^2) \end{pmatrix}$
 $g(x) = \begin{pmatrix} 400x_1^3 - 400x_1x_2 + 2x_1 - 2 \\ 200x_2 - 200x_1^2 \end{pmatrix}$
 Hessian matrix is:
 $H(x) = \begin{pmatrix} 1200x_1^2 - 400x_2 + 2 & -400x_1 \\ -400x_1 & 200 \end{pmatrix}$



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