Date :- 25.10.23

INTEGRATION

Indefinite Integrals

(1) $\int x^n \, dx = \frac{x^{n+1}}{n+1} + c, \; n \neq -1$

(2) $\int \frac{1}{x} dx = \log_e |x| + c$

(3) $\int e^x dx = e^x + c$

(4) $\int a^x dx = \frac{a^x}{\log_e a} + c$

(5) $\int \sin x \, dx = -\cos x + c$

(6) $\int \cos x \, dx = \sin x + c$

(7) $\int \sec^2 x \, dx = \tan x + c$

(8) $\int \operatorname{cosec}^2 x \, dx = -\cot x + c$

(9) $\int \sec x \tan x \, dx = \sec x + c$

(10) $\int \operatorname{cosec} x \cot x \, dx = -\operatorname{cosec} x + c$

(11) $\int \cot x \, dx = \log |\sin x| + c$
$= -\log |\operatorname{cosec} x| + c$

(12) $\int \tan x \, dx = -\log |\cos x| + c$
$= \log |\sec x| + c$

(13) $\int \sec x \, dx = \log |\sec x + \tan x| + c$
$= \log \left|\tan \left(\frac{\pi}{4} + \frac{x}{2}\right)\right| + c$

(14) $\int \operatorname{cosec} x \, dx = \log |\operatorname{cosec} x - \cot x| + c = \log \left|\tan \frac{x}{2}\right| + c$

(15) $\int \frac{1}{\sqrt{a^2 - x^2}} dx = \sin^{-1}\left(\frac{x}{a}\right) + c$

(21) $\int dx = x + c$ (22) $\int \frac{dx}{x} = \ln x + c$

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(16) $\int \frac{-1}{\sqrt{a^2-x^2}}\,dx = \cos^{-1}\left(\frac{x}{a}\right)+c$

(17) $\int \frac{1}{a^2+x^2}\,dx = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)+c$

(18) $\int \frac{-1}{a^2+x^2}\,dx = \frac{1}{a}\cot^{-1}\frac{x}{a}+c$

(19) $\int \frac{1}{x\sqrt{x^2-a^2}}\,dx = \frac{1}{a}\sec^{-1}\left(\frac{x}{a}\right)+c$

(20) $\int \frac{-1}{x\sqrt{x^2-a^2}}\,dx = \frac{1}{a}\operatorname{cosec}^{-1}\left(\frac{x}{a}\right)+c$

(21)

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EXERCISE - 9 (a)

1/ (i) $\int 2\,dx$

Ans→ (i) $\int 2\,dx = 2x+c$

(ii) $\int 3x^2\,dx$

Ans→ $\int 3x^2\,dx = 3\frac{x^3}{3}+c = x^3+c$

(iii) $\int 4x^3\,dx$

Ans→ $\int 4x^3\,dx = 4\frac{x^4}{4}+c = x^4+c$

(iv) $\int x^5\,dx$

Ans→ $\int x^5\,dx = \frac{x^6}{6}+c$

(v) $\int x^{31}\,dx$

Ans → $\int x^{31}\,dx = \frac{x^{32}}{32} + c$

(vi) $\int \left(2\sqrt{x} + \frac{3}{\sqrt{x}}\right) dx$

Ans → $\int \left(2\sqrt{x} + \frac{3}{\sqrt{x}}\right) dx$

$= 2\int x^{\frac{1}{2}}\,dx + 3\int x^{-\frac{1}{2}}\,dx = 2\cdot\frac{x^{\frac{1}{2}+1}}{\frac{1}{2}+1} + 3\cdot\frac{x^{-\frac{1}{2}+1}}{-\frac{1}{2}+1} + c$

$= 2\,\frac{x^{\frac{3}{2}}}{\frac{3}{2}} + 3\,\frac{x^{\frac{1}{2}}}{\frac{1}{2}} + c = \frac{4}{3}x^{\frac{3}{2}} + 6x^{\frac{1}{2}} + c$

(vii) $\int \frac{dx}{x\sqrt{x}} = \int x^{-\frac{3}{2}}\,dx$

$= \frac{x^{-\frac{3}{2}+1}}{-\frac{3}{2}+1} + c = \frac{x^{-\frac{1}{2}}}{-\frac{1}{2}} + c = -2x^{-\frac{1}{2}} + c$

(viii) $\int \left(x^{\frac{4}{7}} + \frac{1}{x^{\frac{1}{3}}}\right) dx = \int x^{\frac{4}{7}}\,dx + \int x^{-\frac{1}{3}}\,dx$

$= \frac{x^{\frac{11}{7}}}{\frac{11}{7}} + \frac{x^{\frac{2}{3}}}{\frac{2}{3}} + c = \frac{7}{11}x^{\frac{11}{7}} + \frac{3}{2}x^{\frac{2}{3}} + c$

(ix) $\int \frac{4}{x}\,dx = 4\ln|x| + c$

(x) $\int \left(\frac{3}{x^2} + \frac{1}{x^{12}}\right) dx$

$= 3\int x^{-2}\,dx + \int x^{-12}\,dx$

$= 3\frac{x^{-1}}{-1} + \frac{x^{-11}}{-11} + c$

$= -\frac{3}{x} - \frac{1}{11}\cdot\frac{1}{x^{11}} + c$

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(xi) $\int (x^2+\sqrt{x})^2 dx$

$= \int (x^4 + x + 2x^2 \cdot \sqrt{x}) dx$

$= \int x^4 dx + \int x \, dx + 2\int x^{\frac{5}{2}} dx$

$= \frac{1}{5}x^5 + \frac{1}{2}x^2 + 2 \times \frac{2}{7} x^{\frac{7}{2}} + C$

$= \frac{1}{5}x^5 + \frac{1}{2}x^2 + \frac{4}{7}x^{\frac{7}{2}} + C$

(xii) $\int (x+3)(2-x) dx$

$= \int (2x+6 - x^2 - 3x) dx$

$= \int (-x^2 - x + 6) dx$

$= -\frac{1}{3}x^3 - \frac{1}{2}x^2 + 6x + C$

(xiii) $\int \frac{(\sqrt{x}+2)^2}{x^4} dx$

$= \int \frac{x+4+2 \cdot 2\sqrt{x}}{x^4} dx$

$= \int (x^{-3} + 4x^{-4} + 4x^{-\frac{7}{2}}) dx$

$= \frac{x^{-2}}{-2} + 4\frac{x^{-3}}{-3} + 4\frac{x^{-\frac{5}{2}}}{-\frac{5}{2}} + C$

$= -\frac{1}{2} \cdot \frac{1}{x^2} - \frac{4}{3} \cdot \frac{1}{x^3} - \frac{8}{5} \cdot \frac{1}{x^{5/2}} + C$

(xiv) $\int \frac{(x+\sqrt{x})(2x+1)}{x^2} dx$

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$$= \int \frac{2x^2 + x + 2x^{\frac{3}{2}} + x^{\frac{1}{2}}}{x^2}\, dx$$

$$= \int \left\{ 2 + \frac{1}{x} + 2x^{-\frac{1}{2}} + x^{-\frac{3}{2}} \right\} dx$$

$$= 2x + \ln|x| + \frac{2x^{\frac{1}{2}}}{\frac{1}{2}} + \frac{x^{-\frac{1}{2}}}{-\frac{1}{2}} + c$$

$$= 2x + \ln|x| + 4\sqrt{x} - \frac{2}{\sqrt{x}} + c$$

1/ $R = \{(m,n) : \frac{m}{n}$ is a power of 5$\}$ on $Z - \{0\}$

Soln

Reflexive:

let $m \in Z - \{0\}$

$\frac{m}{m} = 1 = 5$

So, $(m,m) \in R$

So, R is reflexive

Symmetric:

$m, n \in Z - \{0\}$

let $(m,n) \in R$

$\Rightarrow \frac{m}{n} = 5^k$

$\Rightarrow \frac{n}{m} = \frac{1}{5^k} = 5^{-k}$

$\therefore (n,m) \in R$

So, R is symmetric

Transitive:

$m, n, p \in Z - \{0\}$

let $(m,n) \in R$ and $(n,p) \in R$

$\Rightarrow \frac{m}{n} = 5^{k_1}$ ——— (i)

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$= \frac{n}{p} = 5^{k_2}$ ——— (ii)

eqn (i) × eqn (ii)

$\Rightarrow \frac{m}{\cancel{n}} \times \frac{\cancel{n}}{p} = 5^{k_1} \cdot 5^{k_2}$

$\Rightarrow \frac{m}{p} = 5^{k_1+k_2}$

$(m,p) \in R$

R is transitive

R is reflective, symmetric and transitive so, R is an equivalence relation.

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2) $\tan\left(\cos^{-1}\frac{4}{5} + \tan^{-1}\frac{2}{3}\right)$

Ans ⇒ Let $\cos^{-1}\frac{4}{5} = \alpha$, $\sin\alpha = \sqrt{1-\cos^2\alpha}$

$= \sqrt{1-\left(\frac{4}{5}\right)^2}$

$\Rightarrow \frac{4}{5} = \cos\alpha$

$= \sqrt{1-\frac{16}{25}}$

$\tan = \frac{\sin\alpha}{\cos\alpha} = \tan\alpha = \frac{3}{4}$

$= \sqrt{\frac{25-16}{25}}$

$= \frac{\frac{3}{\cancel{5}}}{\frac{4}{\cancel{5}}}$ $\Rightarrow \alpha = \tan^{-1}\frac{3}{4}$

$= \sqrt{\frac{9}{25}} = \frac{3}{5}$

$\tan\left(\tan^{-1}\frac{3}{4} + \tan^{-1}\frac{2}{3}\right)$

$\tan\left(\tan^{-1}\frac{\frac{3}{4}+\frac{2}{3}}{1-\frac{3}{4}\times\frac{2}{3}}\right)$

$= \left(\tan\tan^{-1}\frac{17}{12} \times \frac{2\cancel{1}}{\cancel{4}7}\right)$ $= \frac{17}{6}$

$\tan\left(\tan^{-1}\frac{17}{6}\right)$

(3)

Minimize $z = 4x + 3y$

subject to $x + y \le 50$ —— (i)

$x + 2y \le 80$ —— (ii)

$2x + y \ge 20$ —— (iii)

$x, y \ge 0$

Ans→

Step-1 Taki.

(4)(i) $\int \cos x \, dx$

Ans→ $\int \cos dx = \sin x + c$

(ii) $\int \frac{dx}{\cos^2 x}$

Ans→ $\int \frac{dx}{\cos^2 x} = \int \sec^2 x \, dx = \tan x + c$

(iii) $\int \frac{dx}{1 - \cos^2 x}$

Ans→ $\int \frac{dx}{1 - \cos^2 x} = \int \frac{dx}{\sin^2 x} = \int \operatorname{cosec}^2 x \, dx$

$= -\cot x + c$

(iv) $\int \frac{\sin x}{\cos^2 x} dx = \int \frac{\sin x}{\cos x} \cdot \frac{1}{\cos x} dx$

$= \int \sec x \cdot \tan x \, dx = \sec x + c$

(v) $\int \frac{2\cos x}{1 - \cos^2 x} dx = 2 \int \frac{\cos x}{\sin^2 x} dx$

$= 2 \int \frac{1}{\sin x} \cdot \frac{\cos x}{\sin x} dx$

$= 2 \int \operatorname{cosec} x \cdot \cot x \, dx$

$= -2 \operatorname{cosec} x + c$

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(vi) $\int \frac{1-\sin^3 x}{\sin^2 x} \cdot dx = \int (\operatorname{cosec}^2 x - \sin x)\, dx$

$= \left(\frac{1}{\sin^2 x} - \frac{\sin^3 x}{\sin^2 x}\right) dx$

$= -\cot x + \cos x + C$

(vii) $\int \frac{\sin^2 x}{1+\cos x}\, dx = \int \frac{\sin^2 x\,(1-\cos x)}{1-\cos^2 x}\, dx$

$= \int \frac{\sin^2 x\,(1-\cos x)}{\sin^2 x}\, dx$

$= \int (1-\cos x)\, dx$

$= \int dx - \int \cos x\, dx = x - \sin x + C$

(viii) $\int \frac{\cos 2x}{\cos x + \sin x}\, dx = \int \frac{\cos^2 x - \sin^2 x}{\cos x + \sin x}$

$= \int (\cos x - \sin x)\, dx = \sin x + \cos x + C$

(ix) $\int \frac{\cos^4 - \sin^4 x}{\cos x - \sin x}\, dx$

$= \int \frac{(\cos^2 x + \sin^2 x)(\cos x - \sin x)(\cos x + \sin x)\, dx}{(\cos x - \sin x)}$

$= \int (\cos x + \sin x)\, dx = \sin x - \cos x + C$

(x) $\int \frac{\cos 2x}{\sin^2 x \cdot \cos^2 x}\, dx = \int \left(\frac{\cancel{\cos^2 x}}{\frac{\sin^2 x}{\cancel{\cos^2 x}}} - \frac{\cancel{\sin^2 x}}{\frac{\cancel{\sin^2 x}}{\cos^2 x}} \right)$

$=$

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$$= \int \frac{\cos^2 x - \sin^2 x}{\sin^2 x \cos^2 x}\,dx = \int \left(\frac{\cos^2 x}{\sin^2 x \cos^2 x} - \frac{\sin^2 x}{\sin^2 x \cos^2 x} \right) dx$$

$$= \int (\operatorname{cosec}^2 x - \sec^2 x)\,dx$$

$$= -\cot x - \tan x + C$$

(xvi) $\displaystyle \int \frac{a^2 \sin^2 x + b^2 \cos^2 x}{\sin^2 2x}\,dx$

$$= \int \frac{a^2 \sin^2 x + b^2 \cos^2 x}{4 \sin^2 x \cdot \cos^2 x}\,dx$$

$$= \frac{a^2}{4} \int \sec^2 x\,dx + \frac{b^2}{4} \int \operatorname{cosec}^2 x\,dx$$

$$= \frac{a^2}{4} \tan x - \frac{b^2}{4} \cot x + C$$

(xvii) $\displaystyle \int (\tan x + \cot x)^2\,dx$

$$= \int \left(\frac{\sin x}{\cos x} + \frac{\cos x}{\sin x} \right)^2 dx$$

$$= \int \left(\frac{\sin^2 x + \cos^2 x}{\cos x \cdot \sin x} \right)^2 dx$$

$$= \int \frac{1}{\sin^2 x \cdot \cos^2 x}\,dx$$

$$= \int \frac{\sin^2 x + \cos^2 x}{\sin^2 x \cdot \cos^2 x}$$

$$= \int (\sec^2 x + \operatorname{cosec}^2 x)\,dx = \tan x - \cot x + C$$

(xviii) $\displaystyle \int \frac{1 - \cos 2x}{1 + \cos 2x}\,dx = \int \frac{2\sin^2 x}{2\cos^2 x}\,dx$

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$= \int \tan^2 x\,dx = \int (\sec^2 x - 1)\,dx$

$= \tan x - x + C$

(xiv) $\int \sec^2 x \cdot \operatorname{cosec}^2 x\,dx$

$= \int \frac{1}{\sin^2 x \cos^2 x}\,dx$

$= \int \frac{\sin^2 x + \cos^2 x}{\sin^2 x \cdot \cos^2 x}$

$= \int (\sec^2 x + \operatorname{cosec}^2 x)\,dx$

$= \tan x - \cot x + C$

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(xv) $\int \frac{a\sin^3 x + b\cos^3 x}{\sin^2 x \cdot \cos^2 x}\,dx$

$= \int \left\{ \frac{a\sin^3 x}{\sin^2 x \cdot \cos^2 x} + \frac{b\cos^3 x}{\sin^2 x \cdot \cos^2 x} \right\} dx$

$= \int \left\{ a\frac{\sin x}{\cos^2 x} + b\frac{\cos x}{\sin^2 x} \right\} dx$

$= \int (a\sec x \cdot \tan x + b\operatorname{cosec} x \cdot \cot x)\,dx$

$= a\int \sec x \cdot \tan x\,dx + b\int \operatorname{cosec} x \cdot \cot x\,dx$

$= a\sec x - b\operatorname{cosec} x + C$

(xvi) $\int \sqrt{1 + \sin 2x}\,dx$

$= \int \sqrt{\cos^2 x + \sin^2 x + 2\sin x \cdot \cos x}\,dx$

$$= \int \sqrt{(\cos x + \sin x)^2}\, dx$$

$$= \int (\cos x + \sin x)\, dx$$

$$= \sin x - \cos x + c$$

(xvii) $$\int \sqrt{1-\cos 2x}\, dx = \int \sqrt{2\sin^2 x}\, dx$$

$$= \sqrt{2} \int \sin x\, dx = -\sqrt{2} \cos x + c$$

(xviii) $$\int \sqrt{1+\cos 2x}\, dx = \int \sqrt{2} \cos x\, dx$$

$$= \int \sqrt{2} \cos x\, dx$$

$$= \sqrt{2} \sin x + c$$

(xix) $$\int \frac{\cos 3x \cdot \cos 2x + \sin 3x \cdot \sin 2x}{1-\cos^2 x}\, dx$$

$$= \int \frac{\cos(3x-2x)}{1-\cos^2 x}\, dx$$

$$= \int \frac{\cos x}{\sin^2 x}\, dx = \int \frac{1}{\sin x} \cdot \frac{\cos x}{\sin x}\, dx$$

$$= \int \operatorname{cosec} x \cdot \cot x\, dx = -\operatorname{cosec} x + c$$

(xx) $$\int (a \cot x + b \tan x)^2\, dx$$

$$= \int \{a^2 \cot^2 x + b^2 \tan^2 x + 2ab \cot x \cdot \tan x\}\, dx$$

$$= \int (a^2 \cot^2 x + b^2 \tan^2 x + 2ab)\, dx$$

$$= a^2 \int \cot^2 x\, dx + b^2 \int \tan^2 x\, dx + 2ab \int dx$$

$$= a^2 \int \cot^2 x\, dx + b^2 \int \tan^2 x\, dx + 2ab \int dx$$

$$= a^2 \int (\operatorname{cosec}^2 x - 1)\, dx + b^2 \int (\sec^2 x - 1)\, dx + 2abx + c$$

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$= a^2(-\cot x - x) + b^2(\tan x - x) + 2abx + C$

$= b^2 \tan x - a^2 \cot x - x(a^2 + b^2 - 2ab) + C$

$= b^2 \tan x - a^2 \cot x - (a-b)^2 x + C$

$= b^2 \tan x - a^2 \cot x + C$

3) (i) $\int (e^x + 2)\,dx = \int e^x dx + 2\int dx$

$= e^x + 2x + C$

(ii) $\int 3^x dx = \frac{3^x}{\ln 3} + C$

(iii) $\int a^{x+2} dx = \int a^2 a^x dx$

$= a^2 \cdot \frac{a^x}{\ln a} + C = \frac{a^{x+2}}{\ln a} + C$

(iv) $\int a^{3x} dx = \frac{1}{3}\frac{a^{3x}}{\ln a} + C$ $= \frac{a^{3x}}{3 \ln a} + C$

let $3x = t$

$\frac{d3x}{dx} = \frac{dt}{dx}$

$\Rightarrow 3 = \frac{dt}{dx}$

$\Rightarrow dx = \frac{dt}{3}$

$\int a^{3x} dx$

$= \int a^t \cdot \frac{dt}{3}$

$= \frac{1}{3}\int a^t dt$

$= \frac{1}{3} \cdot \frac{a^t}{\ln a}$

$= \frac{1}{3} \cdot \frac{a^{3x}}{\ln a}$

$= \frac{a^{3x}}{3 \ln a} + C$

(v) $\int \frac{e^{2x}+1}{e^x} dx = \int (e^x + e^{-x})\,dx$

$= e^x - e^{-x} + C$

28.10.23

4) (i) $\int \left(\frac{5}{\sqrt{1-x^2}} + \frac{7}{1+x^2}\right) dx$

$= 5\int \frac{dx}{\sqrt{1-x^2}} + 7\int \frac{dx}{1+x^2}$

$= 5 \sin^{-1} x + 7 \tan^{-1} x + C$

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(ii) $$\int \frac{3x^2}{x^2+1}\,dx$$

$$= 3\int \frac{(x^2+1)-1}{x^2-1}\,dx$$

$$= 3\int \left\{1-\frac{1}{x^2+1}\right\}dx$$

$$= 3\left\{x-\tan^{-1}x\right\}+C$$

(iii) $$\int \frac{x^6}{x^2+1}\,dx = \int \frac{(x^6+1)-1}{x^2+1}\,dx$$

$$= \int \frac{x^6+1}{x^2+1}\,dx - \int \frac{dx}{x^2+1}$$

$$= \int \frac{(x^2)^3+1}{x^2+1}\,dx - \int \frac{dx}{x^2+1}$$

$$= \int \frac{(x^2+1)(x^4-x^2+1)}{x^2+1}\,dx - \int \frac{dx}{x^2+1}$$

$$= \int (x^4-x^2+1)\,dx - \int \frac{dx}{1+x^2}$$

$$= \frac{1}{5}x^5 - \frac{1}{3}x^3 + x - \tan^{-1}x + C$$

(iv) $$\int \frac{x^4+x^3+x^2+x+2}{x^2+1}\,dx$$

$$= \int \frac{(x^4+x^2)+(x^3+x)+2}{x^2+1}\,dx$$

$$= \int \frac{x^2(x^2+1)+x(x^2+1)+2}{x^2+1}\,dx$$

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$= \int \left\{x^2 + x + \frac{2}{x^2+1}\right\} dx = \int \frac{(x^2+1)(x^2+x)+2}{x^2+1}\, dx = \int \frac{(x^2+1)(x^2+x)}{(x^2+1)}\, dx + \int \frac{2}{x^2+1}\, dx$

$= \frac{2}{3}x^3 + \frac{1}{2}x^2 + 2\tan^{-1}x + C$

(v) $\int \left\{\sqrt{1-x^2} + \frac{x^2}{\sqrt{1-x^2}}\right\} dx$

$= \int \left\{\frac{1-x^2+x^2}{\sqrt{1-x^2}}\right\} dx = \int \frac{dx}{\sqrt{1-x^2}}$

$= \sin^{-1}x + C$

(vi) $\int \frac{x^2+\sqrt{x^2-1}}{x^3\sqrt{x^2-1}}\, dx$

$= \int \left\{\frac{1}{x\sqrt{x^2-1}} + \frac{1}{x^3}\right\} dx$

$= \int \frac{dx}{x\sqrt{x^2-1}} + \int x^{-3}\, dx$

$= \sec^{-1}x + \frac{x^{-3+1}}{-3+1} + C$

$= \sec^{-1}x - \frac{1}{2x^2} + C$

[Antiderivative = Integration

(5) Ans → $F(x) = \int f(x)\, dx = \int (2x^2+1)\, dx$

$= \frac{2}{5}x^3 + x + C$

But $F(0) = -2$

$\therefore -2 = C$

Thus $F(x) = \frac{2}{3}x^3 + x - 2$

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