Grand Finale
Finals

Integral Cup

IIT Bombay

September 8, 2025

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GRAND FINALE

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The finale

Five minutes per integral

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Question 1

$$\int_{-1}^{1} \sqrt{5x^2 + 33 + 2\sqrt{6x^4 + 91x^2 + 200}}\,\mathrm{d}x$$

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Question 1

$$\int_{-1}^{1} \sqrt{5x^2 + 33 + 2\sqrt{6x^4 + 91x^2 + 200}}\, \mathrm{d}x$$

$$= \boxed{\sqrt{11} + 3\sqrt{3} + \frac{8\sqrt{3}}{3} \ln\left(\frac{\sqrt{3}+\sqrt{11}}{2\sqrt{2}}\right) + \frac{25\sqrt{2}}{2} \ln\left(\frac{3\sqrt{3}+\sqrt{2}}{5}\right)}$$

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Question 2

$$\int_{-1}^{1} \frac{1}{1-\cfrac{x}{1+x-\cfrac{x^2}{1+x^2-\cfrac{x^3}{1+x^3-\cdots\cfrac{x^{2025}}{1+x^{2025}}}}}}\,\mathrm{d}x$$

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Question 2

$$\int_{-1}^{1} \cdots \, \mathrm{d}x$$

$$= \boxed{2\sum_{k=0}^{2025} \frac{1}{1+2k(4k+1)} + \frac{1}{1+(2k+2)(4k+3)}}$$

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Question 3

$$\int_{\pi/2}^{3\pi/2} \arcsin\left(\sqrt{\ln(x)}\right)\,\mathrm{d}x$$

we ignore this question right now, the limits are wrong! but the main idea was using integration by parts, i'll give a corrected solution in a pdf i will make and send soon

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$$= \boxed{\frac{3\pi}{2}\arcsin\sqrt{\ln\frac{3\pi}{2}} - \frac{\pi}{2}\arcsin\sqrt{\ln\frac{\pi}{2}} - \sum_{k\geq 1}\frac{\binom{2k-1}{k}}{k!2^{k-1}}\pi}$$

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Question 4

$$\int_{\pi}^{\infty} \frac{\log_{\pi}(e)}{\pi x^2} \frac{x\pi^{\pi/x} - \pi^2}{1 - \log_{\pi} x} \, \mathrm{d}x$$

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Question 4

$$\int_{\pi}^{\infty} \frac{\log_{\pi}(e)}{\pi x^2} \frac{x\pi^{\pi/x} - \pi^2}{1 - \log_{\pi} x} \, \mathrm{d}x$$

$$= \boxed{\sum_{k\geq 1} \frac{\ln(k) \ln^k \pi}{\pi k!} - \ln 2}$$

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Question 5

$$\int_{-1}^{1} \sum_{a=1}^{2025} \sum_{b=1}^{2025} \left\lfloor \frac{x}{a+b} - \frac{1}{2} - \left\lfloor \frac{x}{a+b} \right\rfloor \right\rfloor \sin(a\pi x) \sin(b\pi x) \, \mathrm{d}x$$

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Question 5

$$\int_{-1}^{1} \sum_{a=1}^{2025} \sum_{b=1}^{2025} \left\lfloor \frac{x}{a+b} - \frac{1}{2} - \left\lfloor \frac{x}{a+b} \right\rfloor \right\rfloor \sin(a\pi x) \sin(b\pi x)\, \mathrm{d}x$$

$$= \boxed{-\frac{2025}{2}}$$

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Question 6

$$\int_0^{\pi} \arctan\left(\sin^2 x\right)\, \mathrm{d}x$$

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Question 6

$$\int_0^{\pi} \arctan\left(\sin^2 x\right)\, \mathrm{d}x$$

$$= \boxed{\pi \arctan\left(\sqrt{\frac{1}{\sqrt{2}} - \frac{1}{2}}\right)}$$

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Question 7

$$\int_0^{5!} \sum_{n=0}^{\infty} \left\{ \frac{x}{n!} \right\} \mathrm{d}x$$

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Question 7

$$\int_0^{5!} \sum_{n=0}^{\infty} \left\{ \frac{x}{n!} \right\} \mathrm{d}x = \boxed{5!(60e - 100)}$$

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Tiebreaker 1

$$\int_0^1 \log^2(1-x)\log^2(1+x)\,\mathrm{d}x$$

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Tiebreaker 1

$$\int_0^1 \log^2(1-x)\log^2(1+x)\,\mathrm{d}x$$

$$= \boxed{\begin{aligned} &24 - 8\zeta(2) - 8\zeta(3) - \zeta(4) + 8\log(2)\zeta(2) \\ &\quad - 4\log^2(2)\zeta(2) + 8\log(2)\zeta(3) - 24\log 2 \\ &+ 12\log^2(2) - 4\log^3(2) + \log^4(2) \end{aligned}}$$

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Tiebreaker 2

$$\int_0^1 \frac{1}{(1+yx)\sqrt{1-x^2}}\,\mathrm{d}x$$

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Tiebreaker 2

$$\int_0^1 \frac{1}{(1+yx)\sqrt{1-x^2}}\,\mathrm{d}x$$

$$= \boxed{\frac{\arccos(y)}{\sqrt{1-y^2}}}$$

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Tiebreaker 3

$$\int_0^{\pi/2} \frac{x^3}{\sin^2(x)}\,\mathrm{d}x$$

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Tiebreaker 3

$$\int_0^{\pi/2} \frac{x^3}{\sin^2(x)}\,\mathrm{d}x$$

$$= \boxed{\frac{3}{8}\left(\pi^2 \ln 4 - 7\zeta(3)\right)}$$