

# Free Download Problem From Heck 45 Prove That The Integrals $\cos x^2 dx$

Problem from Heck #45

Prove that the integrals  $\int_0^\infty \cos(x^2) dx$  and  $\int_0^\infty \sin(x^2) dx$  converge.

**Answer.** Since both functions  $x \mapsto \cos(x^2)$  and  $x \mapsto \sin(x^2)$  are continuous in  $\mathbb{R}$ , the only convergence issue happens at infinity. We will thus show that the integrals  $\int_1^\infty \cos(x^2) dx$  and  $\int_1^\infty \sin(x^2) dx$  converge, for reasons which will be explained later.

We show both results simultaneously by showing that the complex-valued integral  $\int_1^\infty e^{ix^2} dx$  converges; the ones we are looking for are its real and imaginary parts. We use a change of variable  $x = \sqrt{u}$  and integration by parts:

$$\int_1^\infty e^{ix^2} dx = \int_1^\infty \frac{1}{2\sqrt{u}} e^{iu} du \quad (1)$$

$$= \left[ \frac{1}{2\sqrt{u}} e^{iu} \right]_1^\infty + \int_1^\infty \frac{1}{4iu\sqrt{u}} e^{iu} du \quad (2)$$

Keeping in mind that  $|e^{iu}| = 1$  for all  $u \in \mathbb{R}$ , we can see that the left summand converges, and the integral on the right is absolutely convergent. This was all we needed to show.

Note that if we had allowed  $x$ , and therefore  $u$ , to live in a neighbourhood of  $0$ , neither of the summands in (2) would be convergent (although their sum still would be, of course). The easiest way out of this mess was to avoid introducing convergence issues where none existed to start with.



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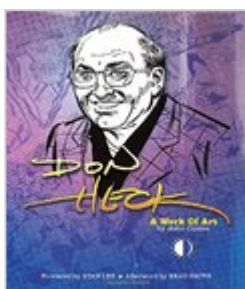
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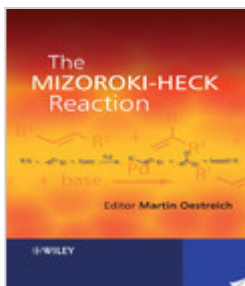
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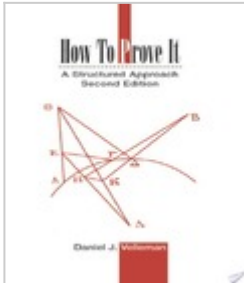




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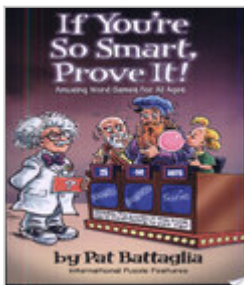
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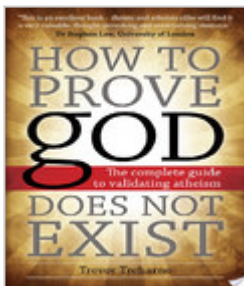
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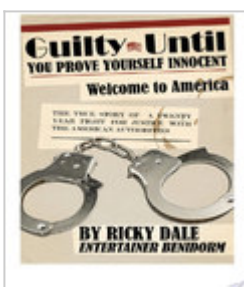
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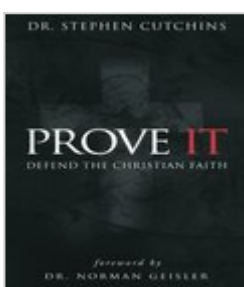
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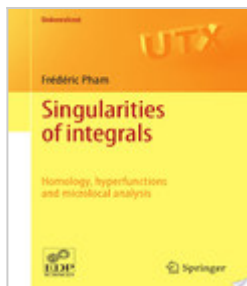
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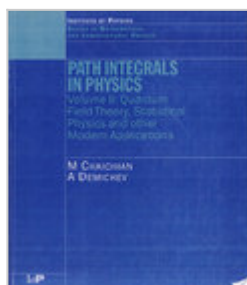
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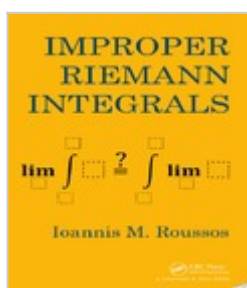
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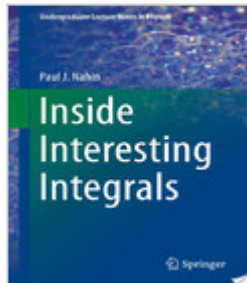
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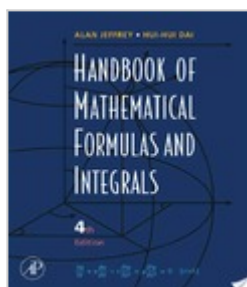
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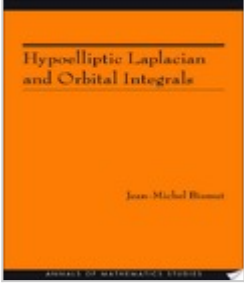
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