

$$3. \int_0^1 \cot^p x \, dx$$

$$\lim_{x \rightarrow 0^+} \frac{x^{-p}}{\cot^p x}$$

$$= \lim_{x \rightarrow 0^+} \frac{\sin^p x}{x^p \cos^p x}$$

$$= \int_0^1 \text{so, same as } \int_0^1 x^{-p} \, dx$$

Converges for $0 < p < 1$ and
diverges for $p \geq 1$.