Work out the following problems and simplify your answers.

1. (30 pts) Evaluate the following integrals.

   (a) $\displaystyle\int t\sin(3t)\,\mathrm{d}t$ (b) $\displaystyle\int_{-1}^{1}\frac{1}{x}\,\mathrm{d}x$

2. (20 pts) Consider the sequence $\{a_n\}_{n=1}^{\infty}$ where $a_n = \dfrac{n+1}{n} - \dfrac{n+2}{n+1}$.
   (a) Does the sequence $\{a_n\}$ converge? If so, find its limit. If not, explain why not.
   (b) Using the sequence $\{a_n\}$ given in the problem, does $\displaystyle\sum_{n=1}^{\infty} a_n$ converge? If so, find its sum. If not, explain why not.

3. (20 pts) The Maclaurin series for $\operatorname{sinc} x = \dfrac{\sin x}{x}$ is $\displaystyle\sum_{n=0}^{\infty}(-1)^n\frac{x^{2n}}{(2n+1)!}$.
   (a) Find the radius of convergence of the series.
   (b) Using the series, what is the value of sinc(0)?
   (c) With the series above in mind, compute the sum of $\displaystyle\sum_{n=0}^{\infty}(-1)^n\frac{\pi^{2n}}{(2n+1)!\,6^{2n}}$.

4. (25 pts) The following problems are related.
   (a) Find the 3rd degree Taylor polynomial $T_3(x)$ centered at $a = 1$ of $\ln x$.
   (b) Estimate the error in using T_3 to approximate $\ln x$ at $x = \dfrac{3}{2}$.

5. (25 pts) Suppose the trajectory of a projectile launched from a cannon is given by the parametric curve

   $$x = 10 - 10e^{-t},\ y = 11 - 11e^{-t} - t, \qquad t \geq 0$$

   where t is the time from launch. Setup, **but do not evaluate**, integrals to find the following:
   (a) The distance the projectile has traveled from $t = 0$ to $t = 10$.
   (b) The area between the trajectory and the x-axis from $t = 1$ to $t = 5$.

6. (30 pts) Consider the two polar equations $r = 4\cos\theta$ and $r = 2$. Answer the following:
   (a) Sketch both polar curves and label their intersections.
   (b) Find the area of the region inside of $r = 4\cos\theta$ and outside of $r = 2$.