1. Calculate the following
   (a) Rectangular coordinates of the following points given in terms of their polar coordinates $(r, \theta)$: $(2\sqrt{3}, \frac{\pi}{3})$ and $(-5, \frac{3\pi}{2})$
   (b) All the polar representations of the following points given in terms of rectangular coordinates: $(\sqrt{6}, \sqrt{2})$ and $(-3, 3)$

2. Sketch the following curves given by polar equations. First plot the points corresponding to the following values of $\theta$: $0, \frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{\pi}{2}, \frac{3\pi}{4}, \pi, \frac{3\pi}{2}, 2\pi$
   (a) $r = \dfrac{12\theta}{pi}$ (b) $r = \dfrac{\theta \sin\theta}{\pi}$

3. Convert the following equations. Can you guess what the curves are?
   (a) Rectangular to polar: $x^2 + y^2 = 2xy$ (b) Polar to rectangular: $r = 2\sin\theta$

4. Limits and continuity
   (a) $\overrightarrow{r}(t) = \left\langle \frac{t}{e^t},\ \cos t,\ \frac{\ln(1+t)}{t} \right\rangle$. For what values of $t$ is $\overrightarrow{r}$ continuous? Calculate $\lim\limits_{t\to 0} \overrightarrow{r}(t)$.
   (b) $\overrightarrow{r}(t) = \langle \tan t,\ \cot t,\ t \rangle$. For what values of $t$ is $\overrightarrow{r}$ continuous. Calculate $\lim\limits_{t\to\pi} \overrightarrow{r}(t)$.

5. Sketch the following curves (plot at least 5 points on each curve)
   (a) $\overrightarrow{r}(t) = \langle t, 2t\sin t, 3t\cos t \rangle, \quad t \geq 0$ (b) $\overrightarrow{r}(t) = \langle t^3, t^2 \rangle$

6. For a curve given by a vector function $\overrightarrow{r}$, the **tangent vector** at $\overrightarrow{r}(t)$ is the vector $\overrightarrow{r}'(t)$. The **unit tangent** at $\overrightarrow{r}(t)$ is the unit vector along $\overrightarrow{r}'(t)$, and the **tangent line** at $\overrightarrow{r}(t)$ is the line passing through $\overrightarrow{r}(t)$ and having $\overrightarrow{r}'(t)$ as the direction vector. Let

$$\overrightarrow{r}(t) = \Big\langle\ (4 + \cos 4t)\cos t,\ (4 + \cos 4t)\sin t,\ \sin 4t\ \Big\rangle, \quad 0 \leq t \leq 2\pi$$

   (a) Calculate $\overrightarrow{r}'(t)$.
   (b) What are the tangent and unit tangent vectors at $\overrightarrow{r}(\pi)$ and the point $\left\langle \frac{3}{\sqrt{2}}, \frac{3}{\sqrt{2}}, 0 \right\rangle$?
   (c) What are the tangent lines at those two points to the curve?

7. Evaluate the following the following $\left(\frac{d}{dt}\overrightarrow{r}(t) = \overrightarrow{r}'(t)\right)$

(a) $\dfrac{d}{dt}\langle t^2,\ e^t,\ \ln t\rangle$

(b) $\dfrac{d}{d\theta}\langle\ 2(\theta - \sin\theta),\ 2(1-\cos\theta)\ \rangle$

(c) $\displaystyle\int_0^{10}\langle t,\ t^2,\ t^3\rangle dt$

(d) $\displaystyle\int_0^{2\pi}\langle\ 2(\theta - \sin\theta),\ 2(1-\cos\theta)\ \rangle d\theta$

(e) $\displaystyle\int_{-1}^{1}\left\langle\ 2t\sqrt{1+t^2},\ e^t,\ 2t^2+1\ \right\rangle dt$

8. (**Bonus**) Consider the sun located at the origin $O = (0,0)$, the earth (E) is rotating around the sun at a distance $10r$ (at constant speed). The moon (M) is rotating around the earth at a distance $r$ from the earth (again at constant speed relative to earth). During one complete rotation by earth around sun the moon rotates 10 times around earth.

(a) Find a parametric equation for the curve traced out by the moon.

(b) Sketch the curve that you obtained.