Most of the following are modified versions of exercises from Stewart’s *Multivariable Calculus*.


37. (13.2 & 13.4) Marianne and Rick’s airplane is being chased by a bad guy in a helicopter. Suppose their trajectories are given by the parametric equations $r_P(t) = \langle 7t - 11, t^2, t + 3 \rangle$ and $r_H = \langle t^2 - 1, 5t - 6, t^2 + 1 \rangle$ for $0 \leq t \leq 5$. Let $C_P$ and $C_H$ denote the corresponding space curves.

(a) Graph $C_P$ and $C_H$. Do $C_H$ and $C_P$ intersect?
(b) Do the helicopter and airplane collide? Justify your answer.
(c) If they do collide, what is the angle between their tangent lines at the point of collision?
(d) Describe the velocity and acceleration of each of the vehicles.

38. (13.3) The Fresnel cosine integral, $C$, and the Fresnel sine integral, $S$, are defined by

$$C(\odot) = \int_0^{\odot} \cos(u^2) \, du \quad \text{and} \quad S(\odot) = \int_0^{\odot} \sin(v^2) \, dv.$$ 

The command in MatLab for the function $S$ is *fresnels* and for $C$ it is *fresnelc*. To see what $S$ and $C$ look like we use MatLab.

```matlab
>> t = -4:.01:4;
>> S = fresnels(t);
>> C = fresnelc(t);
>> plot(t, S, '-r', t, C, '-k');
>> axis equal;
```

MatLab code

(a) The Cornu spiral is the space curve parameterized by the vector valued function $\vec{r}(t) = \langle S(t), C(t) \rangle$ for $t \in \mathbb{R}$. Use MatLab to graph $\vec{r}(t)$ for $-5 \leq t \leq 5$.
(b) Show that $\vec{r}(t)$ parameterizes the Cornu spiral by arc length.
(c) Show that, for $t \geq 0$, the curvature of a Cornu spiral is a linear function of arc length.
(d) Cornu spirals are used in civil engineering – for example, when designing exit ramps for highways. Why do you think they might be used in such a way?

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20 As in the movie *Bird on a Wire*.
21 This means: express your answer as a vector valued function.
22 Also known as a spiro, Euler curve, or clothoid.
39. (13.3 & 13.4) Consider the circle involute of Exercise 29.

(a) If $\theta > 0$, is the acceleration vector $r''(\theta)$ perpendicular to $r(\theta)$? Justify your answer.
(b) What is the length of the curve from $\theta = 0$ to $\theta = b$?
(c) Parameterize the circle involute in terms of arc length.
(d) Compute the curvature of the circle involute.