1. [APPM 2350 Exam (12 pts)] On your paper write the letters (a)-(f) and next to each one write the word TRUE or FALSE as appropriate. No work is required and no partial credit will be given.

   (a) $(\mathbf{u}\cdot\mathbf{v})\times\mathbf{w}=\mathbf{u}\cdot(\mathbf{v}\times\mathbf{w})$

   (b) The cross product of two nonzero vectors that are scalar multiples of each other has magnitude 0.

   (c) $(\mathbf{u}+\mathbf{v})\cdot(\mathbf{u}-\mathbf{v})=\|\mathbf{u}\|^2+\|\mathbf{v}\|^2$

   (d) The intersection of the plane $z=2$ and the surface $4x^2+y^2+4z^2-4y-24z+36=0$ is an ellipse.

   (e) The normal component of the acceleration of a particle moving along a straight line is always zero.

   (f) The unit binormal vector $\mathbf{B}$ for a curve lying in the plane $z=3$ is $\pm\mathbf{k}$.

2. [APPM 2350 Exam (16 pts)] A particle travels along the helix given by $\mathbf{r}(t)=\cos t\,\mathbf{i}+\sin t\,\mathbf{j}+t\,\mathbf{k}$. At time $t=\pi$ the particle leaves the path and flies off on a tangent. Find the location of the particle at $t=2\pi$ assuming no forces act on it after it leaves the helix.

3. [APPM 2350 Exam (10 pts)] Find the equation of, and identify, the quadric surface whose points are equidistant from the point $P_0(2,0,0)$ and the plane containing the point $(-2,0,0)$ whose normal vector is $\mathbf{i}$.

4. [APPM 2350 Exam (28 pts)] The following problems are not related.

   (a) (8 pts) Consider the vector function $\mathbf{r}(t)=\langle t^2,\sin t-t\cos t,\cos t+t\sin t\rangle$ for $0\le t\le c$. Find the value of c for which the arc length is $8\sqrt{5}$.

   (b) (20 pts) Consider the vector function $\mathbf{r}(t)=t\,\mathbf{i}+t^2\,\mathbf{j}+t^3\,\mathbf{k}$ with $-\infty<t<\infty$.

      i. (10 pts) Compute the *torsion*, τ (the measure of the degree of twisting of a curve), given by $\tau=\dfrac{(\mathbf{r}'\times\mathbf{r}'')\cdot\mathbf{r}'''}{\|\mathbf{r}'\times\mathbf{r}''\|^2}$ at the point $(2,4,8)$.

      ii. (10 pts) Are there any points on the curve where the velocity and acceleration vectors are orthogonal? If so, find them. If not, explain why not.

5. [APPM 2350 Exam (34 pts)] Parts (a) and (b) are not related.

   (a) (10 pts) Find the position vector $\mathbf{r}(t)$ of an object subject to the following conditions: it undergoes an acceleration of $e^t\,\mathbf{i}+2t\,\mathbf{j}+(t+1)\,\mathbf{k}$ for $t\ge 0$ and it begins its motion at $\mathbf{i}+2\mathbf{j}+2\mathbf{k}$ with a velocity of $\mathbf{i}+\mathbf{k}$.

   (b) (24 pts) Consider the intersecting lines $L_1(t)=\langle 7-2t,t,-4-t\rangle$ and $L_2(s)=\langle 3+2s,-3+4s,-8+3s\rangle$.

      i. (6 pts) Find the coordinates of the point where the lines intersect.

      ii. (6 pts) Find the equation of the plane containing the lines. Write your final answer in the form $az+by+cz=d$.

      iii. (6 pts) Find the symmetric equations of the line normal to the plane you found in part (ii) and passing through the point you found in part (i).

      iv. (6 pts) Find the coordinates of the point where the line from part (iii) intersects the plane $x+y+z=2$.