Answer the following questions:

**Question 1:**

a) If the function \( f(x) \) is measurable on a set \( E \) and \( S \) is an open set, prove that 
\[ \{ x \in E : f(x) \in S \} \] is measurable on \( E \).

b) Let \( A \) be an algebra of sets and let \( \mu : A \to [0, \infty) \). If \( A \in A \), prove that 
\( \mu(A + d) = \mu(A) \), where \( d \in R \).

c) Let \( R \) be algebra and \( \{ E_i, i = 1, 2, \cdots \} \subseteq R \) be monotonically increasing sequence such that \( \bigcup_{i=1}^\infty E_i \in R \). Show that 
\( \mu\left(\bigcup_{i=1}^\infty E_i\right) = \lim_{n \to \infty} \mu(E_n) \).

d) Prove that 
\( |\mu(A) - \mu(B)| \leq \mu(A \Delta B) \), \( A, B \in R \).

**Question 2:**

a) Complete the following: A set \( S \) is measurable if for every set \( T \)

b) Let \( E_1 \) and \( E_2 \) are measurable sets. Show that \( E_1 \cap E_2 \) is measurable set.

c) Prove that if \( S \) is measurable set then its complement \( \overline{S} \) is measurable.

d) Prove that a countable union of countable sets has measure zero.

**Question 3:**

a) Prove that the Cantor set is measurable and find its measure.

b) Find the torsion on the helix curve \( \vec{r} = (3 \cos t, 3 \sin t, 4t) \).

**Question 4:**

Show how to get the formulas:

i) \( \frac{d}{ds}(\vec{b}(s)) = -\vec{\tau} \times \vec{n} \) \n
ii) \( \frac{d}{ds}(\vec{n}(s)) = -k \vec{\tau} + \vec{\tau} \times \vec{b} \) \n
iii) \( \rho = \frac{1}{|\vec{r} \times \vec{r}|} \)

**Question 5:**

a) Find the equation of the normal line to the surface represented by 
\( f = (u, v) = (v, u, u^2 + v^2) \) at the point corresponding to \( (u, v) = (-1, 1) \).

b) Find the coefficients of the first fundamental form of the regular cone represented by 
\( f = (u, \theta) = (u \cos \theta, u \sin \theta, u) \) and find the length of the arc 
\( u = e^{2\theta} \) on \([0, \pi / 2]\).