Question 1 (20 points). Consider the function \( f \) defined for all \( x \neq 4 \) by
\[
 f(x) = \frac{\sqrt{x} - 2}{x - 4} .
\]

(a) Is \( f \) continuous at the point 4? Give reasons.

(b) If \( f \) is discontinuous at 4, is 4 a \( \underline{\underline{\text{r.e.: s.o.: \: discontinuity}}} \) discontinuity? If it is \( \underline{\underline{\text{s.o.: \: removeable}}} \), prove this by showing how to define \( f(4) \) so as to make \( f \) continuous at 4. Justify your answer.

(d) For the function \( f \) being discussed here: \( \lim_{x \to 4} f(x) \) is \( g'(4) \) for which function \( g \)?
**Question 2** (10 points). Find an interval of length one that contains a solution of the equation $x^5 - x^3 + x^2 = 5$. (State clearly which theorem you are using, show how you are using it, and say why its hypotheses are satisfied.)

**Question 3** (15 points). At the right you see the graph of a function $f$ defined on the whole real line. The graph is composed entirely of line segments, and the function takes the value zero on the intervals $(-\infty, -3]$ and $[3, \infty)$. Answer these questions about $f$ (no reasons required):

(a) At which points of the real line is $f$ differentiable?

(b) On the blank set of axes at the right, sketch the graph of $f'$.

**Question 4** (15 points). Consider the line $x = \pi/2$ to the graph $y = x\sin x$ at the point $(\pi/2, \pi/2)$ on that graph. Does this normal line pass through the point $(\pi, 0)$? Explain your solution clearly.
Question 5 (20 points). (a) Show that: \( \lim_{x \to 0} \frac{1 - \cos x}{x^2} = \frac{1}{2} \).

**Suggestion:** Use the fact that \( \lim_{x \to 0} \frac{\sin x}{x} = 1 \).

(b) Use the result of part (a) to show that \( \lim_{x \to 0} \frac{1 - \cos x}{x} = 0 \).

(This result was important in our proof that the derivative of \( \cos x \) is \( -\sin x \).)
Question 6 (20 points). Differentiate the following functions (show all reasoning). For parts (a) and (b), base your work on the formulas for differentiating sine and cosine.

(a) \( \sec x \) (express your answer in terms of secant and tangent)

(b) \( \tan x \) (express your answer in terms of secant and tangent)

(c) \( \csc x \) (express your answer in terms of cosecant and cotangent)

(d) \( \cot x \) (express your answer in terms of cosecant and cotangent)

(e) \( \frac{1}{(\sin^2 x + \cos^2 x)^2} \) (Look before you leap!)