(1) Find the first 3 nonzero terms of a series solutions corresponding to the larger root of the indicial equation at the regular singular point $x=0$ of the differential equation:

$$2xy'' + y' + xy = 0$$
(2) Consider the equation of heat conduction on a rod of length 40 with the temperature of both ends held at 0:

\[ u_{xx} = u_t \]

Find the first three nonzero terms of the Fourier series for \( u \), given that \( u(x, 0) = f(x) \) and \( u'(x, 0) = 0 \) where \( f(x) = 50 \) if \( 10 < x < 30 \) and \( f(x) = 0 \) otherwise.
Consider the system of equations:

\[ \begin{align*}
x' &= ax + 2y, \\
y' &= -2x \end{align*} \]

a. For what values of \(a\) is the equilibrium at \((0,0)\) stable?
b. For what values is it unstable?
c. For what values do solutions oscillate?
d. Find the general solution to the system of equations in terms of real valued functions when \(a = 2\).
(4) Find all critical points of the following nonlinear system. For each critical point, linearize the system, find the eigenvalues, and indicate whether the equilibrium is stable or unstable.

\[ x'(t) = xy(2 + x) \]
\[ y'(t) = (7 - x)(y + x) \]