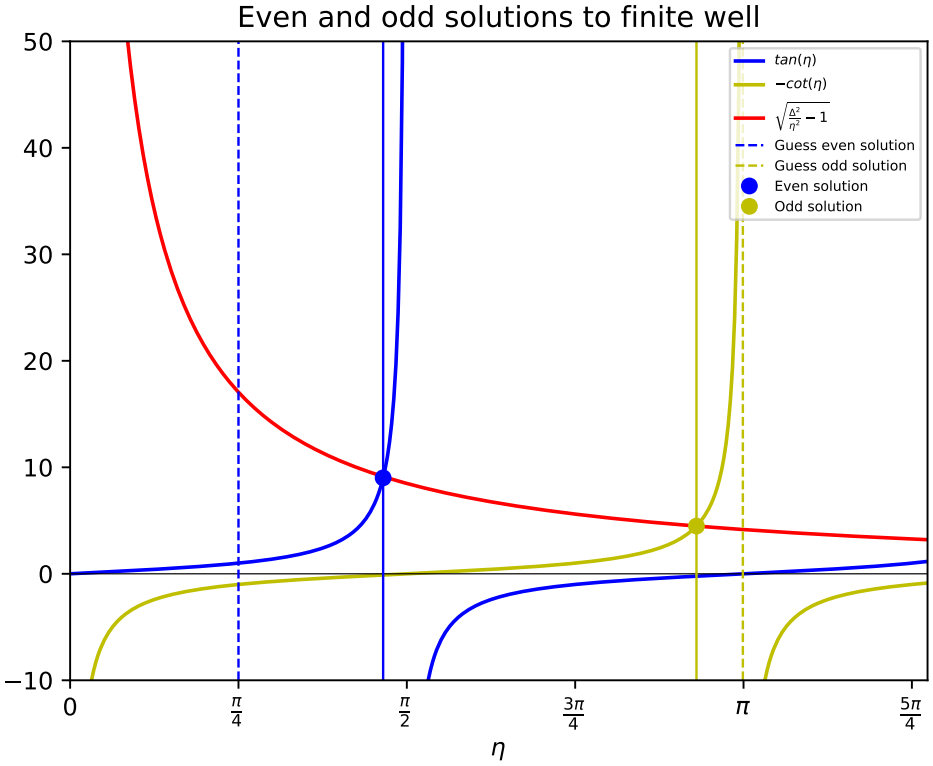
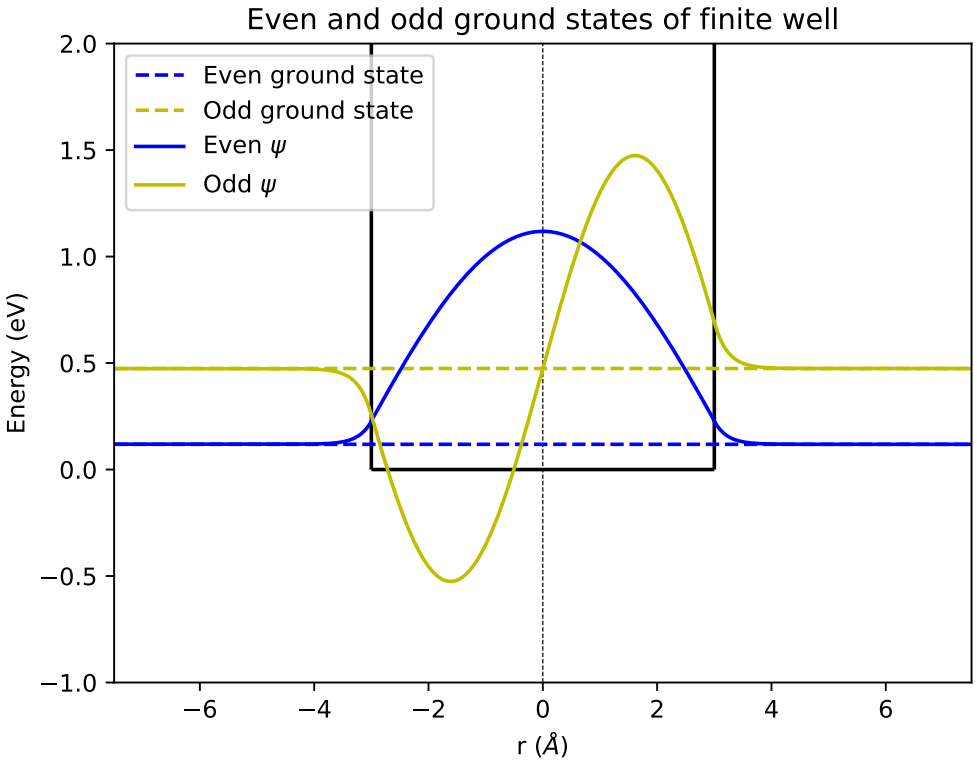
Python code and analysis

```
import numpy as np
import matplotlib.pyplot as plt

a = 3.0                 # the half width of the well in angstroms
m = 1.0                 # mass of electron in 1 me units
V0 = 10.0               # height/depth of well in eV
hbar = 1.0              # hbar
delta = np.sqrt(2.0*m*V0*(a**2.0)/(hbar**2.0))     # Defined in the hand written solution
eta = np.arange(0.001,2*np.pi,0.01)  # Defined in the hand written solutiom

def f(f,eta):
    """
    This is the lhs in the transcendental equations.
    """
    return np.sqrt(((delta/eta)**2.0)-1.0)

def f1(eta):
    """
    The equation whose zeros are to be found to obtain the even solution.
    """
    return f(eta) - np.tan(eta)

def f2(eta):
    """
    The equation whose zeros are to be found to obtain the odd solution.
    """
    return f(eta) + (1.0/np.tan(eta))

def firstDerivative_O4(function,x0,stepsize):
    """
    Returns first derivative of the function "function" at the point x0 by considering points, one and two
     steps on either side of x0.
    The Accuracy is of order (stepsize)^4.
    """
    return (function(x0 - 2.0*stepsize) - 8.0*function(x0 - stepsize) + 8.0*function(x0 + stepsize) -
    function(x0 + 2.0*stepsize))/(12.0*stepsize)

def Newton_Raphson(f,x0,stepsize):
    """
    Returns the zero of f. x0 is the guess. stepsize will be used for determining the first derivative of
    f.
    """
    fprime = firstDerivative_O4(f,x0,stepsize)
    x1 = x0 - (f(x0)/fprime)
    while((x0 - x1) >= stepsize**(8.0)):
        x0 = x1
        fprime = firstDerivative_O4(f,x0,stepsize)
        x1 = x0 - f(x0)/fprime
    return x1

def get_energy(eta):
    """
    Gets energy value for given eta value.
    """
    return (eta**2.0)*(hbar**2.0)/(2.0*m*(a**2.0))

##### Main portion begins #####

even_guess = np.pi/4.0   # Guess for even solution
odd_guess = 0.999*np.pi  # Guess for odd solution
even_sol = Newton_Raphson(f1,even_guess,10**(-3)) # Obtaining the solution using the Newton Raphson method
odd_sol = Newton_Raphson(f2,odd_guess,10**(-3))   # Obtaining the solution using the Newton Raphson method

### Printing the solutions
print("eta for even sol : {etev:0.6f}".format(etev=even_sol))
print("eta for odd sol : {etod:0.6f}".format(etod=odd_sol))
print("Energy for even state is : {e2:0.6f}".format(e2=get_energy(even_sol)))
print("Energy for odd state is : {e1:0.6f}".format(e1=get_energy(odd_sol)))
```

The outputs are shown below :

Even solution (η)	Odd solution (η)	Even energy (eV)	Odd energy (eV)
1.460	2.922	0.118	0.474


Even and odd solutions to finite well
$tan(\eta)$
$-cot(\eta)$
$\sqrt{\frac{\Delta^2}{\eta^2}-1}$
Guess even solution
Guess odd solution
Even solution
Odd solution
50
40
30
20
10
0
−10
0
$\frac{\pi}{4}$
$\frac{\pi}{2}$
$\frac{3\pi}{4}$
π
$\frac{5\pi}{4}$
η


Even and odd ground states of finite well
Even ground state
Odd ground state
Even ψ
Odd ψ
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
Energy (eV)
−6
−4
−2
0
2
4
6
r (Å)