1. Log in to your Sage/Cocalc account.
   
   (a) Start Firefox or Chrome browser.
   (b) Go to http://cocalc.com
   (c) Click “Sign In”.
   (d) Click project Classroom Worksheets.
   (e) Click “New”, call it c34, then click “Sage Worksheet”.

Now we will define a new graph function for computing the hard-to-compute stability number of a graph. The stability number of a graph is the largest number of vertices in the graph that have no edges between them.

So our problem of finding a maximum stable set in a graph can be reduced to the problem of finding a maximum stable set in two smaller subgraphs: (1) the graph formed by removing vertex \( v \) and (2) the graph formed by removing \( v \) and its neighbors. In this case, we assume that \( v \) is in the maximum stable set.

Here’s our function to remove a vertex and its neighbors from a graph and produce a new graph with \( v \) and its neighbors removed.

```python
def remove_vertex_and_neighbors(g,v):
    S2=g.vertices()
    S2.remove(v)
    for w in g.neighbors(v):
        S2.remove(w)
    return g.subgraph(S2)
```

2. So now let’s fix up our algorithm. We’ll make \( V \) pop a vertex off the end. That won’t effect out original graph. Now we know how to define \( S1 \) and \( S2 \) to be what we want.

```python
def tt_maximum_stable_set(g):
    V = g.vertices()
    S1 = V
    v = S1.pop()
    S2 = remove_vertex_and_neighbors(g,v)
    g1 = g.subgraph(S1)
    g2 = g.subgraph(S2)
    Max1 = tt_maximum_stable_set(g1)
    Max2 = tt_maximum_stable_set(g2)
    if len(Max1) > len(Max2):
        return Max1
    else:
        return Max2
```
Evaluate. Let $g = \text{graphs.PetersenGraph()}$ and then try \texttt{tt\_maximum\_stable\_set(g)}. We get a \texttt{pop from empty list} error. Ooooh. Yeah, we didn’t think about that. At some point, after we keep removing vertices, we’ll get an empty list of vertices. At that point we should return that empty list.

```python
def tt_maximum_stable_set(g):
    V = g.vertices()
    if V == []:
        return V
    S1 = V
    S2 = copy(V)
    v = S1.pop()
    S2 = remove_vertex_and_neighbors(g, v)
    g1 = g.subgraph(S1)
    g2 = g.subgraph(S2)
    Max1 = tt_maximum_stable_set(g1)
    Max2 = tt_maximum_stable_set(g2)
    if len(Max1) > len(Max2):
        return Max1
    else:
        return Max2
```

Evaluate. Then try \texttt{tt\_maximum\_stable\_set(g)}. What happened? We \texttt{know} that’s not the answer.

3. We forgot that when we remove $v$ and its neighbors that we are assuming $v$ is in a maximum stable set. So somehow we need to keep track of our maximum stable set and include $v$ in that. Let’s let \texttt{StableSet} be the (current) maximum stable set. That’s also what we should return if the vertex set is empty.

```python
def tt_maximum_stable_set(g, StableSet):
    V = g.vertices()
    if V == []:
        return StableSet
    v = V.pop()
    S1 = V
    S2 = remove_vertex_and_neighbors(g, v)
    g1 = g.subgraph(S1)
    g2 = g.subgraph(S2)
    Max1 = tt_maximum_stable_set(g1, StableSet)
    Max2 = tt_maximum_stable_set(g2, StableSet+[v])
    if len(Max1) > len(Max2):
        return Max1
    else:
        return Max2
```

Try \texttt{tt\_maximum\_stable\_set(g, [])}. Now \texttt{test} this function with a variety of other graphs where you \texttt{know} the answer. Does it work?

4. Now use the \texttt{timeit()} command to compare the speed of the \texttt{naive\_maximum\_stable\_set()} and \texttt{tt\_maximum\_stable\_set()} functions. Use a variety of graphs for test purposes.