1. (20) By comparison with the 1960s, the decade of the 1970s was a time of persistently high unemployment and persistently rising prices. Explain how the adverse oil shock that occurred early in the decade could account for the unemployment observation, but has a harder time accounting for the price observation. (Hint: explain what an oil shock does to the natural rate of unemployment and to the price level. Use the AS-AD framework to explain what happens in the short and medium run after an oil shock.)

- answer: Our analysis of the oil shock suggests that it can produce a permanent rise in the unemployment rate. However, it can only exert an impact on the price level over the medium run of 3-5 years. It is hard to see how the oil shock by itself could raise inflation over a decade. To see that the oil shock can account for the unemployment observation, recall how we modeled it by an increase in the markup. The higher markup raises the natural rate of unemployment. The reason for this is that the higher markup corresponds to a lower real wage for workers and our bargaining model can only sustain this if the unemployment rate is higher (the price setting curve in the graph with W/P on the vertical axis and unemployment on the horizontal axis, shifts up..the wage setting curve does not shift.) In the AS-AD diagram, the higher natural rate of unemployment corresponds to the (low) level of output where price equals the pre-shock expected price. In the short run, the economy moves only part-way down to the lower natural level of output. When the AS curve shifts left, the economy moves northwesterly along the AD curve and stops in the short run at the new intersection of the AD and (new) AS curves. The rise in price and fall in output as one moves northwesterly along the AD curve corresponds to the fact that with a higher price level, the money and goods markets require a lower level of output to be in equilibrium. This is because the higher
price reduces the real value of money balances, which generates a higher interest rate and reduces the investment component of planned spending. In the medium run, people notice that the price level is higher than expected, so expected prices start to rise, shifting the AS curve further to the left. This process stops when the AS curve has shifted left enough so that its intersection with the unchanged AD curve occurs at the new natural level of output. Thus, the medium and short run both involve increases in the unemployment rate and the price level. Since the new equilibrium unemployment rate is higher, the model has no problem accounting for persistently higher unemployment as a result of the adverse oil shock. However, note that the price level ceases to change in the new equilibrium. In the new medium run equilibrium, the inflation rate is predicted to be what it was in the old equilibrium: zero. Since the medium run equilibrium is expected to be attained in 3-5 years, the model has a hard time accounting for the observation that prices continued to rise throughout the 1970s.

2. It is said that a change in the saving rate cannot change the growth rate of the economy in the long run, but that it can nevertheless change the growth rate for a while. Explain.

- The analysis should be done with a graph having output, saving and investment per efficiency unit labor on the vertical axis and capital per efficiency on the horizontal. The equilibrium level of capital per efficiency unit labor is determined by the intersection of the saving and investment function, $s k^\alpha$ with the ‘depreciation’ line, $(\delta + n + g_A)k$. It is the value of $k$, say $k^*$, that satisfies:

$$s (k^*)^\alpha = (\delta + n + g_A)k^*.$$  

If $k$ is less than $k^*$, then $k$ will increase. If $k$ exceeds $k^*$, then $k$ will decrease. This value of $k$ determines equilibrium output per efficiency unit of labor, $y^* = (k^*)^\alpha$. Regardless of the saving rate, since $k^*$ and $y^*$ are fixed in long-run equilibrium, the growth rate of actual output and the capital stock are just $n + g_A$. The saving rate has nothing to do with this. Now, if the saving rate should
suddenly rise, this creates a new long run capital per efficiency unit of labor, $k^{**}$. Since $k^* < k^{**}$, $k$ will start to rise. But, since $k = K/(LA)$, for $k$ to rise means that $K$ must grow faster than $LA$, i.e., faster than $n + g_A$. This will happen throughout the period in which $k \to k^{**}$. During this period, $y \to (k^{**})^\alpha$ and so output, $Y$, also grows faster than $n + g_A$. Thus, a change in the saving rate can generate a transitory change in the growth rate of the economy. But, it cannot change it permanently.

3. Many used to believe in the following proposition, ‘The principle of diminishing marginal productivity of capital implies that eventually the day must come when growth in output per person comes to a stop.’ Explain why someone might believe this proposition. Explain why the continual arrival of new ideas can indefinitely put off the day when per capita output growth must stop.

- Suppose the production function is given by $Y = K^\alpha L^{1-\alpha}$, so that $(Y/L) = (K/L)^\alpha$, where $0 < \alpha < 1$. Then, with any fixed saving rate the saving function, $s(K/L)^\alpha$, must eventually cross the depreciation line, $(\delta + n)(K/L)$. After that, no further growth in $K/L$ and $Y/L$ can occur. If $K/L$ were somehow to increase higher, $(\delta + n)(K/L)$ would exceed $s(K/L)^\alpha$ and $K/L$ would start to fall. Now, if the production function were instead $Y = K^\alpha (A L)^{1-\alpha}$, then $s(K/L)^\alpha (A)^{1-\alpha}$ would be increasing in $A$. Suppose $A$ were constant. Then the previous observations apply, and the day would eventually come when growth in $K/L$ would cease. That’s the day when $s(K/L)^\alpha A^{1-\alpha} = (\delta + n)(K/L)$. Suppose now that $A$ increased, say due to the arrival of new ideas, then long run equilibrium $K/L$ would increase too. In effect, the rise in $A$ offsets the fall in $s(K/L)^\alpha (A)^{1-\alpha}$ that occurs as $K/L$ rises. As long as $A$ kept on rising, $K/L$ and, hence, $Y/L$ would keep rising. Thus, new ideas can offset the deadening effect on growth of the principle of diminishing marginal utility of capital.

4. Suppose you observe an economy in which recessions are preceding by a sudden, sharp increase in the rate of interest. As the recession proceeds, output and the interest rate both fall. What two shocks could
be the underlying cause of recessions in this economy? Explain. What additional data would you need to see to determine which of the two is the one that is actually at work? Explain.

- A positive shock to money demand, or a negative shock to money supply would have the effects described. Both shift the LM curve left. That creates an instantaneous overshooting in the rate of interest, after which output and the interest rate fall to their short run equilibrium with a lower price level and level of output. In the medium run, the AS curve shifts right as \( P^e \) comes down, and the economy returns to its natural rate of output and its natural rate of unemployment. You could tell if it were money supply or money demand by looking at the stock of money. If it doesn’t move, it was money demand. If it did move, it was money supply.

5. Suppose the production function is given by \( Y = K^\alpha (LA)^{1-\alpha} \), \( \alpha = \frac{1}{3} \), \( \frac{K}{Y} = 3 \). The rate of depreciation on capital is \( \delta \), so that if \( K \) is the capital at the beginning of the year, the wear and tear on it during the year is \( \delta K \). Suppose that \( \delta = 0.04 \). The economy is known to be in a long-run equilibrium, and the growth rate of output is 0.03, i.e., 3%.

(a) Suppose there is perfect competition in this economy. What is the share of income going to the owners of capital? What role does the assumption of perfect competition play in your argument?

(b) The Golden Rule ratio, \( k = K/(LA) \), is that value of \( k \) that maximizes, in long-run equilibrium, \( c = C/(LA) \). Derive a simple expression that can be used to test whether this economy is at the Golden Rule value of \( k \). Show that it is in fact below the Golden Rule.

(c) What policies could be adopted to move the economy toward the Golden Rule? What are the considerations in favor and against implementing this policy?

- answer: the rental rate of capital is \( r = MPK = dY/dK = \alpha k^{\alpha-1} = \alpha Y/K \). This (e.g., \( r = MPK \)) is the profit maximization condition for firms which take \( r \) as given, as competitive firms do. To see this, note that their profits are \( F(K,L) - rK - wL \).
Assuming $r$ does not change with $K$ (this assumption will be false if firms have market power in resource markets), then the profit maximizing condition (easily verified using the graphical technique displayed in class) is $MPK = r$. The share of income going to capital is, therefore, $rK/Y = \alpha$, or, $1/3$.

- The Golden Rule value of $k$, $k^G$, maximizes $k^\alpha - (\delta + n + g_A)k$, the value of consumption (divided by labor, in efficiency units) in a long run equilibrium. This is achievable by the saving rate, $s = (\delta + n + g_A)k/k^\alpha$. $k^G$ solves $MPK = \delta + n + g_A$. This result is easy to see graphically: the $k$ where the vertical distance between $k^\alpha$ and $(\delta + n + g_A)k$ is maximized corresponds to the point where the slope of these two curves are equal. This gives us a way to test whether we’re at the Golden Rule. We have that $MPK = \frac{1}{3} \times \frac{1}{3} = .11$. The growth rate of output is $n + g_A = .03$. So, $MPK > \delta + n + g_A = 0.07$. We’re below the Golden Rule.

- To get to the Golden Rule, implement a policy that raises the saving rate (the government could subsidize saving). This is easily seen in the appropriately constructed graph. Moving to the Golden Rule has the advantage of eventually raising the level of consumption permanently. But, it comes at the cost of depressing the consumption of the current generation. The latter is what enables the capital stock to be built up, to make possible the higher consumption of later generations. Whether this policy is viewed as desirable depends on how you weight the welfare of current versus future generations.