1. In this question, we examine two special cases of the sticky-price model developed in this chapter. In the sticky-price model, all firms have a desired price \( p \) that depends on the overall level of prices \( P \) as well as the level of aggregate demand \( Y - \bar{Y} \). We wrote this as

\[
p = P + \alpha(Y - \bar{Y}).
\]

There are two types of firms. A proportion \( (1 - s) \) of the firms have flexible prices and set prices using the above equation. The remaining proportion \( s \) of the firms have sticky prices—they announce their prices in advance based on the economic conditions that they expect in the future. We assume that these firms expect output to be at its natural rate, so \( EY - \bar{Y} \) = 0. Hence, these firms set their prices equal to the expected price level:

\[
p = EP.
\]

The overall price level is a weighted average of the prices set by the two types of firms:

\[
P = sEP + (1 - s)[P + \alpha(\bar{Y} - Y)].
\]

Rearranging:

\[
P = EP + [\alpha(1 - s)/s](\bar{Y} - Y).
\]

a. If no firms have flexible prices, then \( s = 1 \). The above equation tells us that

\[
P = EP.
\]

That is, the aggregate price level is fixed at the expected price level: the aggregate supply curve is horizontal in the short run, as assumed in Chapter 9.

b. If desired relative prices do not depend at all on the level of output, then \( \alpha = 0 \) in the equation for the price level. Once again, we find \( P = EP \): the aggregate supply curve is horizontal in the short run, as assumed in Chapter 9.

2. The economy has the Phillips curve:

\[
\pi = \pi_{-1} - 0.5(\mu - 0.06).
\]

a. The natural rate of unemployment is the rate at which the inflation rate does not deviate from the expected inflation rate. Here, the expected inflation rate is just last period's actual inflation rate. Setting the inflation rate equal to last period's inflation rate, that is, \( \pi = \pi_{-1} \), we find that \( \mu = 0.06 \). Thus, the natural rate of unemployment is 6 percent.

b. In the short run (that is, in a single period) the expected inflation rate is fixed at the level of inflation in the previous period, \( \pi_{-1} \). Hence, the short-run relationship between inflation and unemployment is just the graph of the Phillips curve: it has a slope of \( -0.5 \), and it passes through the point where \( \pi = \pi_{-1} \) and \( \mu = 0.06 \). This is shown in Figure 13–1. In the long run, expected inflation equals actual inflation, so that \( \pi = \pi_{-1} \), and output and unemployment equal their natural rates. The long-run Phillips curve thus is vertical at an unemployment rate of 6 percent.

c. To reduce inflation, the Phillips curve tells us that unemployment must be above its natural rate of 6 percent for some period of time. We can write the Phillips curve in the form

\[
\pi - \pi_{-1} = 0.5(\mu - 0.06).
\]

Since we want inflation to fall by 5 percentage points, we want \( \pi - \pi_{-1} = -0.05 \). Plugging this into the left-hand side of the above equation, we find

\[
-0.05 = -0.5(\mu - 0.06).
\]
We can now solve this for $u$:

$$u = 0.16.$$  

Hence, we need 10 percentage points of cyclical unemployment above the natural rate of 6 percent.

Okun's law says that a change of 1 percentage point in unemployment translates into a change of 2 percentage points in GDP. Hence, an increase in unemployment of 10 percentage points corresponds to a fall in output of 20 percentage points. The sacrifice ratio is the percentage of a year's GDP that must be forgone to reduce inflation by 1 percentage point. Dividing the 20 percentage-point decrease in GDP by the 5 percentage-point decrease in inflation, we find that the sacrifice ratio is $20/5 = 4$.

d. One scenario is to have very high unemployment for a short period of time. For example, we could have 16 percent unemployment for a single year. Alternatively, we could have a small amount of cyclical unemployment spread out over a long period of time. For example, we could have 8 percent unemployment for 5 years. Both of these plans would bring the inflation rate down from 10 percent to 5 percent, although at different speeds.

3. a. Beginning in long-run equilibrium, where output is at the natural level, if the Federal Reserve increases the money supply, this will cause the economy to go through an expansionary phase. Starting with the IS-LM model in Figure 13-2A, an increase in the money supply will shift the LM curve to the right, resulting in a lower interest rate and higher level of output at point B. In the long run, the price level will rise, real-money balances will decline, and the LM curve will shift back to its original position. There is no long-run change in the real interest rate or the level of output. Moving to the AD-AS model in Figure 13-2B, an increase in the money supply will shift the AD curve to the right, resulting in a higher level of output and a higher price level at point B. In the long run, expected inflation will rise, shifting the SRAS curve upward. The economy ends up at point C with output back at its natural level and the price level at a higher level. Moving to the Phillips curve graph in Figure 13-2C, the economy starts at point A, where unemployment is at the natural rate. The increase in the money supply pushes output above its natural level, and as a result, the unemployment rate falls below its natural level. This causes a movement along the short-run Phillips curve to point B, where inflation is higher and unemployment is lower. In the long run, expected inflation will rise, causing the Phillips curve to shift upward. The economy ends up at point C with higher inflation and no change in the unemployment rate. The economy moves through this expansionary cycle because the increase in the money supply does not immediately cause expected inflation to rise.
b. Beginning in long-run equilibrium with output at its natural level, if the Federal Reserve increases the money supply and people immediately expect inflation to rise, then nothing changes except for the price level and the inflation rate. In the IS–LM model, the increase in the money supply will cause the price level to rise at the same rate as the money supply such that there is no change in real balances. The economy stays at point A, as illustrated in Figure 13-3A. Moving to the AD–AS model, the increase in the money supply shifts the AD curve to the right, but at the same time, the increase in expected inflation shifts the SRAS curve up and to the left. The economy remains at the natural level of output and the price level is higher, as illustrated in Figure 13-3B. Moving to the Phillips curve, the immediate increase in expected inflation shifts the short-run Phillips curve upward, causing the inflation rate to rise with no change in the unemployment rate, as illustrated in Figure 13-3C. When the money supply increases and the public immediately expects higher inflation, the economy does not move through an expansionary cycle.
4. In this model, the natural rate of unemployment is an average of the unemployment rates in the past two years. Hence, if a recession raises the unemployment rate in some year, then the natural rate of unemployment rises as well. This means that the model exhibits hysteresis: short-term cyclical unemployment affects the long-term natural rate of unemployment.

a. The natural rate of unemployment might depend on recent unemployment for at least two reasons, suggested by the theory of hysteresis. First, recent unemployment rates might affect the level of frictional unemployment. Unemployed workers lose job skills and find it harder to get jobs; also, unemployed workers might lose some of their desire to work, and hence search less hard for a job. Second, recent unemployment rates might affect the level of structural unemployment. If labor negotiations give a greater voice to "insiders" than "outsiders," then the insiders might push for high wages at the expense of jobs. This will be especially true in industries in which negotiations take place between firms and unions.

b. If the Fed seeks to reduce inflation permanently by 1 percentage point, then the Phillips curve tells us that in the first period we require

$$\pi_1 - \pi_0 = -1 = -0.5(u_1 - u_2^n),$$

or

$$(u_1 - u_2^n) = 2.$$ 

That is, we require an unemployment rate 2 percentage points above the original natural rate $u$. Next period, however, the natural rate will rise as a result of the cyclical unemployment. The new natural rate $u$ will be

$$u = 0.5[u_1 + u_2^n]$$

$$= 0.5[(u_1^n + 2) + u_2^n]$$

$$= u_1^n + 1.$$ 

Hence, the natural rate of unemployment rises by 1 percentage point. If the Fed wants to keep inflation at its new level, then unemployment in period 2 must equal the new natural rate $u$. Hence,

$$u_2 = u_1^n + 1.$$ 

In every subsequent period, it remains true that the unemployment rate must equal the natural rate. This natural rate never returns to its original level: we can show this by deriving the sequence of unemployment rates:
\[ u_2 = (1/2)u_3 + (1/2)u_4 = u + 1.5 \]
\[ u_4 = (1/2)u_3 + (1/2)u_2 = u + 1.25 \]
\[ u_n = (1/2)u_n + (1/2)u_3 = u + 1.375. \]

Unemployment always remains above its original natural rate. In fact, we can show that it is always at least 1 percent above its original natural rate. Thus, to reduce inflation by 1 percentage point, unemployment rises above its original level by 2 percentage points in the first year, and by 1 or more percentage points in every year after that.

c. Because unemployment is always higher than it started, output is always lower than it would have been. Hence, the sacrifice ratio is infinite.

d. Without hysteresis, we found that there was a short-run tradeoff but no long-run tradeoff between inflation and unemployment. With hysteresis, we find that there is a long-run tradeoff between inflation and unemployment: to reduce inflation, unemployment must rise permanently.