Question 1: AD-AS (30 points)

Consider the following closed economy:

\[ C^d = 200 + 0.5(Y - T) - 200r \quad \text{(consumption)} \]
\[ I^d = 250 - 300r \quad \text{(investment)} \]
\[ L = 0.5Y - 500i \quad \text{(real money demand)} \]
\[ \bar{Y} = 1000 \quad \text{(full employment output)} \]
\[ \pi^e = 0 \quad \text{(expected inflation)} \]

Suppose \( G = T = 200 \), and \( M = 4500 \).

1. Derive an equation for the \( IS \) curve. (5 points)

   Solution:

\[
S^d = Y - C^d - G \\
= Y - (200 + 0.5(Y - T) - 200r) - G \\
= Y - (200 + 0.5(Y - 200) - 200) - 200 \\
= 0.5Y - 300 + 200r \\
I^d = 250 - 300r \\
S^d = I^d \iff 0.5Y - 300 + 200r = 250 - 300r \\
IS: Y = 1100 - 1000r
\]

2. Derive an equation for the \( LM \) curve. (5 points)

   Solution:

\[
\frac{M^s}{P} = 0.5Y - 500(r + \pi^e) \\
LM: \frac{4500}{P} = 0.5Y - 500r
\]
3. Derive an equation for the aggregate demand curve. (5 points)

Solution:

\[ LM \Leftrightarrow 1000r = Y - \frac{9000}{P} \]
\[ IS = LM \Leftrightarrow Y = 1100 - (Y - \frac{9000}{P}) \]
\[ AD : Y = 550 + \frac{4500}{P} \]

4. What are the general equilibrium values of output, consumption, investment, the real interest rate, and price level?

Solution:

\[ Y = \bar{Y} = 1000 \]
\[ AD = AS \Leftrightarrow 1000 = 550 + \frac{4500}{P} \]
\[ \Leftrightarrow P = \frac{4500}{450} = 10 \]
\[ IS : 1000 = 1100 - 1000r \]
\[ \Leftrightarrow 1000r = 100 \Leftrightarrow r = 0.1 \]
\[ I = 250 - 300r = 250 - 300(0.1) = 220 \]
\[ C = 200 + 0.5(Y - T) - 200r = 200 + 0.5(1000 - 200) - 200(0.1) = 580 \]
\[ Y = C + I + G = 580 + 220 + 200 = 1000 = \bar{Y} \]

5. Following any shock to the economy, price setting firms are incapable of adjusting prices for one period (they must supply any level of demanded output at the prevailing price level), after which price adjustment is fully flexible. Calculate the short-run and long-run impact on \( Y \) and \( P \) when the Federal Reserve unexpectedly expands the money supply to \( M = 5000 \). Graph the AS-AD dynamics. (10 points)

Solution: In the first period, \( P \) remains fixed at \( P = 10 \) (i.e., horizontal SRAS curve), after which \( P \) will fully adjust so \( Y = \bar{Y} \) (i.e., vertical LRAS). In the short run:

\[ AD : Y = 550 + \frac{M^*}{P} = 550 + \frac{5000}{10} = 1050 \]
In the long-run (the subsequent period):

\[ Y = \bar{Y} = 1000 \]

\[ AD : 1000 = 550 + \frac{5000}{P} \Leftrightarrow P = \frac{100}{9} \]

**Question 2: (15 points)**

What is the cyclical behavior of the real wage and labor productivity? What do the following business cycle theories predict about the cyclical behavior of the real wage, and is it consistent with the data?

**Solution:** Real wages and labor productivity are mildly procyclical, although this procyclicality was diminished during the Great Moderation.

a. The Real Business Cycle Theory (5 points)
   
   **Solution:** RBC theory predicts that real wages and average labor productivity are procyclical, but to a greater extent than witnessed in the data. Flexible prices implies vary rapid adjustment of real wages so that the labor market always clears.

b. The New-Keynesian Theory of Sticky Wages. (5 points)

   **Solution:** The New-Keynesian sticky wage model implies that real wages should be counter-cyclical during \( AD \)-driven booms, contrary to the data. Rigid nominal wages suggest that when \( P \) rises following an outward shift of the \( AD \) curve shifts, \( w \) should fall.

c. The New-Keynesian Theory of Sticky Prices. (5 points)

   **Solution:** The New-Keynesian sticky price model implies that real wages should be procyclical during \( AD \)-driven booms, consistent with the data. After a positive \( AD \) shock, firms see an increase in demand for their products and firms with sticky prices must increase production, thus they increase their demand for labor. The rightward shift in labor demand causes the real wage to rise during \( AD \)-driven booms.

**Question 3: (15 points)**

Comment on the following statement: “The Solow residual is strongly positively correlated with output growth. This means that output fluctuations are predominantly caused by exogenous productivity shocks.”

**Solution:** The Solow residual is indeed strongly correlated with output growth. If the
Solow residual were a pure measure of technology, this correlation would suggest that output fluctuations were predominantly caused by exogenous productivity shocks, as RBC theorists believe. But there is reason to believe there is significant measurement error in the Solow residual as an estimate of productivity, notably from the procyclical utilization of capital and labor (suggesting that the standard measure of the Solow residual is more procyclical than true productivity).

Furthermore, the imputed Solow residual appears to be correlated with monetary policy and government purchases (demand shocks), suggesting that it is an imperfect measure of technology and that demand shocks also contribute to output fluctuations. Using alternative measures of technology shocks, Gali (1999) and Basu, Fernald and Kimball (2006) both find that technological innovation decreases hours worked, which suggests that aggregate demand shocks contribute to output fluctuations (“pure” technology shocks alone wouldn’t be able to generate procyclical employment). See ‘Criticisms of RBC theory’ lecture notes.

**Question 4: Macro Concepts (15 points)**

Provide brief explanations for the following

(a) **Phillips curve (5 points)**

    **Solution:** The Phillips curve traditionally describes the negative short-run relationship between unemployment and inflation. The basic intuition is that more slack in the labor market will mean less upward price pressure, as there is less pressure on firms’ marginal costs. But the empirical relationship of the Phillips curve from the 1950s and 60s failed to hold during the stagflation of the 1970s. The economics profession has since widely adopted an expectations-augmented Phillips curve (e.g., the New-Keynesian Phillips curve relates inflation and inflation expectations to the output gap).

(b) **Crowding Out (5 points)**

    **Solution:** An increase in government purchases or a reduction in taxes will usually “crowd out” private investment by pushing up the real interest rate, so that $Y$ increases by less than the rightward shift in the $IS$ curve. Investment (and often consumption) is thought to be a decreasing function of the real interest rate, so an increase of government spending will decrease overall private spending and reshuffle the composition of GDP. The degree of crowd out depends on the relative slopes of the $IS$ and $LM$ curves: There is no crowd-out if the $IS$ curve is vertical (e.g., if
investment doesn’t depend on interest rates) or if the LM curve is horizontal (e.g., if money demand does not depend on income), and there is perfect crowd-out if the LM curve is vertical (e.g., if money demand does not depend on the interest rate).

(c) Policy Ineffectiveness Proposition (5 points)

Solution: The policy ineffectiveness proposition (PIP) states that monetary policy cannot be effective in stabilizing the business cycle, because the only way for monetary policy to hold traction is to surprise agents, but agents will anticipate that the Fed will increase the money supply in recessions and decrease it in booms. This proposition is a direct result of the rational expectations hypothesis, which suggests that the public uses all available data to formulate forecasts of economic variables and policy actions. The PIP applies to all models without nominal rigidities, in particular RBC theory models and neoclassical models with imperfect information (e.g., Lucas’s Island Model and Friedman’s Misperceptions Model).