1. Each part of question 1 is worth 8 points for a total of 24 points.
   
   a. The national savings identity implies that the financing of private investment \( I \) comes from private saving \( S_{\text{pvt}} \), foreign saving \( S_{\text{foreign}} \) and government saving \( S_{\text{govt}} \).
   
   b. The Okun relationship is a negative relationship between the percent change in GDP and the percent change in unemployment.
   
   c. Each factor of production is paid its marginal product so that total payments to labor are \( MPL \cdot L \) and total payments to capital are \( MPK \cdot K \). Euler's theorem implies that economic profits are zero.
   
   d. Investment per worker, male secondary education, life expectancy, and rule of law and democracy indices are positively linked to growth in output per capita. Population growth rate, depreciation rate, female secondary education, initial level of output per worker, fertility rate, government consumption and inflation are negatively linked to growth in output per capita.

2. Part a is worth 12 points, parts b and c are worth 8 points each, and part d is worth 6 points for a total of 34 points.
   
   a. In the labor market, a reduction in welfare benefits shifts the supply of labor curve to the right. This lowers the real wage rate \( W/P \) and increases the quantity of labor \( L \). In the production function with labor on the x-axis, the economy moves along the curve, which increases the level of real GDP \( Y \) in the long-run.

   In the capital market, more labor per unit of capital increases the marginal product of capital. This shifts the demand for capital curve to the right, which raises the real rental rate \( R/P \) and leaves the quantity of labor \( K \) the same. In the production function with capital on the x-axis, the increase in the marginal product of capital shifts the production function up and thus the same quantity of capital produces more real GDP \( Y \) in the long-run.

   b. A reduction in welfare benefits will lead to an increase in real GDP \( Y \) and reduce government payments. Therefore, both private saving \( S_{\text{pvt}} \) and public saving \( S_{\text{govt}} \) increase. In the closed-economy loanable funds market, the increase in national saving shifts the national saving curve to the right. This causes the real interest rate \( r \) to fall which in turn increases real investment \( I \) in the long-run.
c. A reduction in welfare benefits will increase both private saving ($S_{pvt}$) and public saving ($S_{gov}$). In the small, open-economy loanable funds market, the increase in national saving shifts the national saving curve to the right. Since the economy takes the world interest rate ($r^*$) as given, there is no change in the real interest rate ($r$) and real investment ($I$). However, with more national saving and the same amount of real investment, real net exports ($NX$) would increase in the long-run. The increase in real net exports ($NX$) shows up as a decrease in foreign saving ($S_{foreign}$).

d. If Alan Greenspan responds by decreasing the supply of money ($M$), then the level of real GDP ($\bar{Y}$) will not change, but the price level ($P$) will fall. The reason is because money is neutral in the long-run. In other words, a change in a nominal factor like the quantity of money has no effect on real variables like real GDP.

3. Parts a and d are worth 4 points each, parts c and g are worth 6 points each, parts e and f are worth 7 points each, and part b is worth 8 points for a total of 42 points.

a. The production function of the Solow growth model exhibits decreasing returns to scale in capital. This implies that the first and second derivatives of $f(k)$ are positive and negative, respectively.

b.

![The Solow Growth Model](image-url)
c. By substituting the production function and national saving identity into the capital accumulation equation, one gets the following: \( k^n = s \cdot f(k) - (\delta + n)k \). Note that the Solow growth model is now expressed in terms of the endogenous variable \( k \) and the exogenous variables \( s, \delta \) and \( n \). Setting \( k^n \) to zero, the steady-state capital stock per worker \( k^* \) is:

\[
s \cdot f(k^*) = (\delta + n)k^*.
\]

See the picture above for the steady-state capital per worker \( k^* \), output per worker \( y^* \) and consumption per worker \( c^* \).

d. The Golden Rule level of capital per worker \( k_{gold}^* \) is the steady-state level of capital per worker that maximizes consumption per worker. \( MPK = (\delta + n) \) must hold to achieve the Golden Rule level of capital per worker \( k_{gold}^* \).

e. At the onset, an increase in the saving rate \( (s) \) would cause gross investment \( s \cdot f(k) \) to exceed break-even investment \( (\delta + n)k \). This would lead to capital accumulation and thus temporary growth in capital per worker \( k \). However, due to decreasing returns to scale in capital, gross investment \( s \cdot f(k) \) would once again equal break-even investment \( (\delta + n)k \). Therefore, in the Solow growth model, an increase in the saving rate \( (s) \) would increase the level of steady-state capital per worker \( k^* \), but would have no impact on the growth rate of steady-state capital per worker \( k^* \).

f. At the onset, an increase in the saving rate \( (s) \) would cause gross investment \( s \cdot f(k) \) to exceed break-even investment \( (\delta + n)k \). However, due to constant returns to scale in capital, gross investment \( s \cdot f(k) \) would stay above break-even investment \( (\delta + n)k \) forever. Therefore, in an endogenous growth model, an increase in the saving rate \( (s) \) would increase the growth rate of the steady-state capital per worker \( k^* \).

g. Policymakers are so interested in whether growth of output per worker is better described by the Solow growth model or by an endogenous growth model because they have the ability to use tax and other policies to raise saving. If growth is described by Solow, then these policies will only have temporary effects on the growth rate. However, if growth is described by endogenous growth, then these policies will have permanent effects on the growth rate.