1. Consider a world of two countries (US, India) with these demand and supply curves:

US: \[ D = 400 - 5P_c^{US} \quad \text{and} \quad S = 15P_c^{US} \]

INDIA: \[ D = 50 - 2P_c^{India} \quad \text{and} \quad S = 8P_c^{India} \]

where \( P_c^{US} \) is the price of clothing in the US; \( P_c^{India} \) is the price of clothing in India.

a) Find the autarky prices in each country.

US: \[ S^{US} - D^{US} = 20P_c^{US} - 400 = 0 \Rightarrow P_c^{US} = 20 \]

India: \[ S^{India} - D^{India} = 10P_c^{India} - 50 \Rightarrow P_c^{India} = 5 \]

b) Assuming free trade, find the equilibrium world price and quantities traded.

\[ S^{India} - D^{India} = D^{US} - S^{US} \Rightarrow 10P_c^{India} - 50 = 400 - 20P_c^{US} \Rightarrow 30P_c^{US} = 450 \Rightarrow P_c^{US} = P_c^{India} = 15 \]

Exports^{India} = X^{India} = S^{India} - D^{India} = 100 \quad \text{is quantity traded}

India pays (2/3) of the US tax, while US residents pay (1/3). The incidence of the tax is on both the buyer (the importer) and the seller (the exporter).

i. Calculate how a US import tariff of \( t \) affects the volume of trade and prices in India and the US (your answer should be expressed in terms of \( t \)). Who pays for the US import tax? Explain.

{NOTE: under the US import tariff: \( P_c^{US} = P_c^{India} + t \}).

US import demand equals India’s export supply, given the tariff, implies:

\[ 10P_c^{India} - 50 = 400 - 20(P_c^{US}) \Rightarrow 10P_c^{India} - 50 = 400 - 20(P_c^{India} + t) \Rightarrow 30P_c^{India} = 450 - 20t \Rightarrow P_c^{India} = 15 - (2t/3); \quad P_c^{US} = 15 + (t/3); \quad X^{India} = 10P_c^{India} - 50 = 100 - (20t/3); \quad t \leq 15 \]

The US tariff causes US prices to rise, and thus consumers lose, producers gain, and the government gains tariff revenue. In terms of the figure:

\[ \Delta CS = -Area\{15, B, B', (15 + (t/3))\} = -\frac{t}{3} \cdot \left\{ 325 - \frac{5t}{6} \right\} = \frac{-325t}{3} + \frac{5t^2}{18} \]

\[ \Delta PS = Area\{15, A, A', (15 + (t/3))\} = \frac{t}{3} \cdot \left\{ 225 + \frac{5t}{2} \right\} = 75t + \frac{5t^2}{6} \]

Tariff Revenue = \( t(100 - (20t/3)) = 100t - \left( \frac{20t^2}{3} \right) \)
Change Welfare = $\Delta CS + \Delta PS + TR = \frac{200t}{3} - \frac{50t^2}{9} > 0$ for $0 < t < 12$

Overall, in terms of the figure above, the US loses areas 2 and 4 because of the changed output and consumption levels, but gains area 5 due to the improved terms of trade (imports, though less than before, are also cheaper than before).

ii. **Provide a numerical answer to (i) for $t = 6$. Does US welfare rise or fall?**

At $t=6$, US welfare increases by 200.

iii. **Suppose the US import tariff of $t = 6$ were replaced by an import quota of 60 units (no more than 60 units could be imported into the US). What difference, if any, would this change make?**

Since imports are 60 when $t=6$, the import quota and import tariff have the same effect except, with the quota, the US importer makes profits ($6 \times 60 = 360$) equal to the tariff revenue. If the quotas are auctioned off, then the two policies are fully equivalent.

iv. **Using your answer to part i above, find the US import tariff that maximizes US welfare (the sum of consumer surplus, producer surplus and government tariff revenue). Why isn’t free trade optimal for the US?**

From part (i):

$$\Delta W = \Delta CS + \Delta PS + TR = (200t/3) - (50t^2/9) \Rightarrow \frac{dW}{dt} = (200/3) - (100t/9) = 0 \Rightarrow t^* = 6$$
d) Show how the US import tariff of $t$ affects India’s producer surplus, consumer surplus and welfare (the sum of producer and consumer surplus).

(see figure below)

\[ \Delta CS = \text{Area}\{15 - (2t/3); A, A', 15\} = (2t/3)(20 + (2t/3)) \]

\[ \Delta PS = -\text{Area}\{15 - (2t/3); B, B', 15\} = -(2t/3)(120 - (8t/3)) \]

\[ \Delta Welfare = -(200t/3) + \left(20t^2/9\right) \]

In terms of the figure, India loses areas 1, \{A, A', B', B\} – which is the loss due to the decline in their terms of trade.

e) Use your answer to parts (c) and (d) to show how the US export tariff affects world welfare.

US: \[ \Delta W^{\text{us}} = (200t/3) - \left(50t^2/9\right) \]

India: \[ \Delta W^{\text{India}} = -(200t/3) + \left(20t^2/9\right) \]

World: \[ \Delta W^{\text{us}} + \Delta W^{\text{India}} = -\left(10t^2/3\right) \]

i. Assuming the US export tariff reduces world welfare, why doesn’t the US want to unilaterally lower its tariff? Explain.

Because the US gains from its own tariff even though it inflicts higher costs on India.

f) Can India also gain by using an import tariff? Explain.

The only difference between a US import tariff and an Indian export tariff is who collects the tariff revenue. If we call an Indian export tariff $\theta$ and the US import tariff $t$, and $p^w$ the “world” price,
then: \[ p^w = p^w + t; \quad p^{\text{India}} = p^w - \theta \rightarrow p^{\text{us}} = p^{\text{India}} + (t + \theta). \]

Both the US import tariff and the Indian export tariff drive a wedge between US’ and India’s prices. Hence, an Indian export tariff of \( \theta \) will reduce Indian prices by \( (2\theta/3) \) and raise US prices by \( (\theta/3) \) so that US citizens pay part of the Indian tax and hence India can gain from some export tax.

i. **Return to part (cii).** Suppose initially the U.S. has an import tariff of \( t=6 \) and India has no tariff. Assume the U.S. eliminates its import tariff AND India simultaneously imposes an export tariff of \( \theta = 6 \). How would this affect production, consumption and price in each country? How would it effect the welfare of each country?

If the US removes its tariff of 6, and India imposes an export tariff of 6, then production and consumption in each country are unchanged, but the tariff revenue now accrues to India instead of the US. Hence, for each country, from earlier results:

US: 
\[
\Delta CS = -\frac{325t}{3} + \frac{5t^2}{18} \quad \Delta PS = 75t + \frac{5t^2}{6} \quad \Delta W^{\text{us}} = -(100t/3) + \left(10t^2/9\right) = -160 \text{ at } t=6
\]

India: 
\[
\Delta CS = (2t/3)(20 + (2t/3)); \quad \Delta PS = -(2t/3)(120 - (8t/3)); \quad TR = t(100 - (2t/3)) \text{ At } t=6:
\Delta W^{\text{India}} = (100t/3) - \left(40t^2/9\right) = 40
\]

The loss in world welfare is the same as earlier. Using the results, India’s optimal tariff, if the US does not use a tariff, is 
\[
\frac{dW^{\text{India}}}{dt} = (100/3) - (80t/9) = 0 \rightarrow t = \frac{300}{80} = \frac{15}{4}
\]

ii. **Use the above to argue both countries can gain from their own tariff but are hurt by the other country’s tariff.** Is it possible to have an equilibrium where both the US and India have tariffs, both are worse off than under free trade and yet neither country wants to unilaterally eliminate its tariff? Explain {this is called a prisoner’s dilemma}.

As explained in class, each country has an incentive to restrict trade. Since world efficiency falls, at least one country must lose from this practice. If the countries are of fairly similar size and have similar elasticities of import demand or export supply, then it is quite likely that both countries lose. However, neither country has the unilateral incentive to remove its tariff.

2. **(Free Trade Area)** Consider a simple partial equilibrium model of the computer industry. Argentina has the following supply and demand curves:

\[
S = 4p^d; \quad D = 9,000 - 2p^d
\]

Argentina can import (identical) computers from Korea, at exogenous price \( p^K = 700 \), or from Brazil, at \( p^B = 900 \). Argentina is contemplating forming a Free Trade Area with one of the two countries.

a) **Initially tariffs are \( t=400 \) from either country.** Absent an FTA, as long as the tariffs are the same, Argentina would import from Korea and:

\[
p^d = 1,100; \quad q^d = 4,400; \quad c^d = 6,800; \quad \text{Im ports } = M^d = 2,400
\]
b) Argentina forms a free trade area with Korea.

Since Korea is the low cost producer, it imports computers from Korea when the tariff is the same on both countries, and thus it continues to import from Korea if Argentina forms an FTA with Korea. There is no trade diversion, just trade creation and welfare must rise. In terms of the figure above, supply falls from A to A*, and demand increases from B to B*. The welfare changes are:

\[
\Delta CS = \text{Area}\{1100, B, B^*, 700\} = 2,880,000; \quad \Delta PS = -\text{Area}\{1100, A, A^*, 700\} = -1,440,000; \\
\Delta Tar Rev = -\text{Area}\{ABJH\} = -400 \times 2400 = -960,000; \quad \Delta Welfare = 480,000
\]

Overall, in the figure above, triangles 1 & 2 represent the gains due to trade creation.

c) Suppose Argentina forms an FTA with Brazil.

Since Korean imports are still subject to the tariff, the price in Argentina of Korean computers will be 1100, while the price of Brazilian computers will be 900 (since they are not subject to tariffs). **Hence, trade will be diverted from Korea to Brazil.** Since the domestic price of computers falls, there will be more imports – so there is also trade creation. In terms of the figure below:

Domestic price falls from 1100 to 900, consumption increases to 7200, production decreases to 3600, so imports increase from 2400 to 3600 (this is trade creation). But all imports come from Brazil, rather than the original 2400 that were imported from Korea. This is trade diversion.
The welfare effects are:

\[ \Delta CS = Area\{1100, B, B', 900\} = 1,400,000; \quad \Delta PS = Area\{1100, A, A', 900\} = -800,000; \]
\[ \Delta Tar Rev = -Area\{ABJH\} = -400 \times 2400 = -960,000; \quad \Delta Welfare = -360,000 \]

The country gains areas 1 (A',A,M) and 2 (B,B',N) due to trade creation but loses area 3 (M,N,J,H) due to trade diversion – it is paying 200 more for the 2400 computers previously imported from Korea but now imported from Brazil.

d) **Repeat part (c) under the assumption the original tariff had been 600.**

With the higher tariff, initial imports will be smaller and hence trade diversion will be less and trade creation will be more. Consequently, it is more likely the FTA will be beneficial in the case when initial tariffs are higher. In terms of the figure below:

Domestic price falls from 1300 to 900, consumption increases from 6400 to 7200, production decreases from 5200 to 3600, so imports increase from 1200 to 3600 (this is trade creation). But all imports come from Brazil, rather than the original 1200 that were imported from Korea. This is trade diversion.

The welfare effects are:

\[ \Delta CS = Area\{1300, E, E', 900\} = 2,720,000; \quad \Delta PS = -Area\{1300, D, D', 900\} = -1,760,000; \]
\[ \Delta Tar Rev = -Area\{DEJH\} = -600 \times 1200 = -720,000; \quad \Delta Welfare = 240,000 \]

In terms of the figure below, the gains from trade creation are triangles 5 and 6, the loss from trade diversion is rectangle 7. Overall, the country gains from trade because trade creation is larger and trade diversion smaller than in part (c).
e) Are there any general conclusions you would draw about the benefits of forming an FTA with another country?

A free trade agreement is more likely to be beneficial when: (1) most of your trade is with other members of the FTA, so trade diversion is relatively small; and/or (2) tariffs are initially large, so trade creation is relatively large.

3. Consider a small country (Canada) with the following demand and supply curves for steel:

\[
\text{Supply} = Q' = 8P^s; \quad \text{Demand} = 6600 - 4P^c
\]

Note that \( P^s \) is the price producers (sellers) receive for steel output, \( P^c \) is the price consumers pay for steel, and if there are no domestic taxes or subsidies, then: \( P^c = P^s \). Assume Canada can trade (import or export) steel at a given world price of: \( P^w_s = 600 \) per ton of steel.

Suppose that the domestic production of steel in Canada creates pollution, which damages the local environment. Suppose the estimated (economic) cost of this pollution is 120 per ton of steel produced. Assume there is no domestic policy to counteract the externality.

a) Suppose the world price of steel is 600. Is it possible that allowing steel exports could lower domestic welfare? How does the presence of the externality affect the gains from trade?
Consider the graph below. The lines labeled S and D are the supply and demand curves, as usual. The line labeled “MSC” is marginal social cost, which lies above the supply curve by an amount equal to the cost of pollution (which is 120). The autarky price is 550, but the **efficient autarky price is where MSC intersects demand (which would be 630)**.

The autarky price is 550, but because of the externality too much steel is produced (which means the autarky price is too low). If the world price is 600, Canada will export steel, which worsens the domestic externality of overproduction of steel. Hence, it is possible Canada could lose from trade. (if pollution were taxed, Canada would import steel).

![Graph](image)

i. **Calculate the gains (or losses) from trade in this setting.**

\[ \Delta CS = -Area\{600, A, E, 550\} = -215,000 \]

\[ \Delta PS = Area\{600, B, E, 550\} = 230,000 \]

\[ -\Delta Pollution Cost = -120 \cdot \Delta Q = -120 \cdot 400 = -48,000 \]

\[ \Delta Welfare = -33,000 \]

The main point is that free trade may not improve welfare because it increases pollution costs; in this case, Canada is hurt by trade and, in fact, Canada exports steel while it really should import steel (if pollution costs were included in production costs).
ii. If the government were to use some policy to attack the market failure (the pollution), what policy should it use? Be as specific as possible.

The optimal policy is a pollution tax, which is the same in this case as a production tax of 120 per ton of steel. If it used that tax, the country would actually import steel.

iii. If only trade policy is possible, should the government tax or subsidize steel exports?

Clearly, the government should tax steel exports since steel is overproduced. If you want to calculate the optimal export tax, \( t \), write:

\[
P^d = 600 - t; \quad C = 4200 + 4t; \quad Q = 4800 - 8t; \quad Exports = 600 - 12t; \quad t \leq 50
\]

\[
\Delta CS = t[4200 + 2t]; \quad \Delta PS = -t[4800 - 4t];
\]

\[
Tar. Revenue = t[600 - 12t]; \quad \Delta Poll. Costs = 120(\Delta Q) = 960t
\]

\[
\Delta Welfare = -6t^2 + 960t
\]

If there is no pollution, then the second term above would be zero, and a tariff only lowers welfare. With the pollution the optimal export tariff is:

\[
dW = 960 - 12t = 0 \rightarrow t^* = 80
\]

Since an export tariff of 50 eliminates all trade, the best policy would be to ban exports. In fact, if it is feasible to ban exports and subsidize imports, then an import subsidy of 80 – to reduce the domestic price to 520 – is the optimal trade policy.

b) Suppose now that the world price of steel is 400 so that, with no government policy, the country will import steel. Is it possible that free trade could lower domestic welfare in this case? Why does this case differ from part (a)?

Since the country will import steel, and since the problem is overproduction of steel, then trade must be beneficial in this case.

i. Calculate the gains (or losses) from trade in this setting.

(see figure below)
Autarky: \( P = 550; \quad C = Q = 4400 \)

Free trade: \( P = 400; \quad Q = 3200; \quad D = 5000 \)

\[ \Delta PS = -\{550, E, M, 400\} = -150 \left( \frac{4400 + 3200}{2} \right) = -570,000 \]

\[ \Delta CS = +\{550, E, L, 400\} = 150 \left( \frac{4400 + 5000}{2} \right) = 705,000 \]

Reduction Poll. Costs = 120 * 1200 = 144,000

Thus, welfare rises by 135,000 due to the usual gains from trade plus an additional 144,000 due to reduced pollution costs (total gain is 279,000).

\[ \text{ii. If the government were to use some policy to attack the market failure (the pollution), what policy should it use? Be as specific as possible.} \]

As earlier, the optimal policy is to tax pollution, which is equivalent to taxing production. The tax should be 120 per ton of steel produced.

\[ \text{iii. If only trade policy is possible, should the government tax or subsidize steel imports?} \]

If only trade policy is possible, the goal is to reduce production; hence an import subsidy would be the second-best policy in this case.