1. Consider the case of two large countries:

US: Demand = 2000 - 3P^o; Supply = 7P^o where P^o is the price of oil in the US;

SA: Demand = 500 - 3P^{SA}; Supply = 12P^{SA} where P^{SA} is the price of oil in Saudi Arabia.

(a) Find autarky prices:
   US: S^a^s - D^a^s = 10P^o^a - 2000 = 0 \rightarrow P^o^a = 200
   Saudi Arabia: S^{SA} - D^{SA} = 12P^o^{SA} - (500 - 3P^{SA}) = 15P^o^{SA} - 500 \rightarrow P^o^{SA} = 33\frac{1}{3}

(b) Assuming free trade (no tariffs), find the equilibrium price and quantities traded.
   World equilibrium requires: (S^{a^o} - D^{a^o}) + (S^{SA} - D^{SA}) = 0 \rightarrow 10P^o^a + 15P^o^{SA} - 2500 = 0
   Free trade implies: P^o^a = P^o^{SA} = P^w (world price).
   Combining the above two equations implies: 25P^w - 2500 = 0 \rightarrow P^w = 100
   US imports = Saudi Arabian exports = (S^{SA} - D^{SA}) = 15P^o^{SA} - 500 = 1000


Drop the subscript (o) for oil, for simplicity; the US import tariff implies: P^a^s = P^{SA} + t if the product is to be sold in both the US and Saudi Arabia. This equation, together with the world supply = world demand equation implies:

10P^a^s + 15P^{SA} - 2500 = 10(P^{SA} + t) + 15P^{SA} - 2500 = 0 \rightarrow P^{SA} = 100 - \frac{10}{25}t = 100 - \frac{2t}{5}

Thus, even though the US imposes the tax, only (3/5) is paid by US citizens while (2/5) is paid by Saudi Arabian citizens. There is “partial incidence” of the tax. To calculate the welfare consequences for the US consider the figure below:
(i) Because the tariff increases US price, consumers lose area \{100,B^*,B,(100+0.6t)\} and producers gain area \{(100,A^*,A,100+0.6t)\}. Calculating these areas gives:

\[
\Delta CS = -\left(0.6t\right) \frac{(3400 - 1.8t)}{2} = -\left(1020t - 54t^2\right);
\]
\[
\Delta PS = \left(3t/5\right) \frac{(1400 + 4.2t)}{2} = \left(420t + 126t^2\right)
\]

On the other hand government tariff revenue is \(tM = t(1000 - 6t)\), which is area \{E,A,B,F\}. Hence, the overall welfare impact is:

\[
\Delta W = Area\{E,J,K,F\} - Area\{A,J,A^*\} - Area\{B,K,B^*\} = Rectangle \ 3 - Triangle \ 1 - Triangle \ 2
\]

The last two areas are the familiar losses due to underconsumption and overproduction in the US due to the import tariff. **What is new is the first area** – which represents the gains to the US because Saudi Arabia is receiving a lower price from the US for oil – i.e., the decreased price times the amount imported at that price. This gain to the US is a loss to Saudi Arabia – a transfer from Saudi Arabia to the US because Saudi Arabia pays part of the US tax. In terms of the numbers given here:

\[
\Delta W^{\text{frt}} = \text{Tariff Revenue} + \Delta CS + \Delta PS = t(1000 - 6t) + \left(420t + 126t^2\right) - \left(1020t - 54t^2\right) = 400t - 4.2t^2
\]

The US gains from any tariff such that \(\Delta W > 0 \rightarrow 0 < t < (400 / 4.2) \approx 95.24\).

(ii) For \(t = 40\), US price rises by 24, Saudi Arabian price falls by 16, US consumer surplus decreases by 39,906, US producer surplus increases by 18,816, US imports are 760, US tariff revenue is 30,400 and the change in US welfare is: \(\Delta W = 30,400 - 39,936 + 18,816 = 9,280\). Clearly the US gains from the import tariff.
(iii) What would happen if the import tariff of 40 were replaced by an import quota of 760 units?

With an import quota of 760, since it binds (free trade imports are 1000), we have:

\[
\text{US: } D^w - S^w = 2000 - 10P^w = 760 \rightarrow P^w = 124; \quad \text{Saudi Arabia: } S^{Sl} - D^{Sl} = 15P^{Sl} - 500 = 760 \rightarrow P^{Sl} = 84
\]

Thus, with US imports limited, there would be a price gap of 40 between US and Saudi Arabian prices. Whoever had the right to import into the US (the holders of the quota licenses) would make excess profits of 40. Thus, the only difference between the tariff of 40 and the import quota of 760 is that the government revenue under the tariff becomes excess profits for the importers under the quota. If the quotas are auctioned off, then the two policies are equivalent.

(iv) Find the US import tariff that maximizes US welfare.

From part (i) above we have: \( \Delta W = 400t - 4.2t^2 \)

Maximizing with respect to \( t \):

\[
\frac{d(\Delta W)}{dt} = 400 - 8.4t = 0 \rightarrow t^* = \frac{400}{8.4} \approx 47.62
\]

As stated above, free trade is not optimal for the US because its policies affect world price. Thus, it has the ability to act like a monopsonist on world markets. But, as with monopsony, even though the monopsonist can increase (its own) profits by restricting purchases, the loss to sellers (i.e., Saudi Arabia) exceeds the gains to the firm – there is a deadweight loss. The same is true of the US import tariff – the loss to the Saudis exceeds the gains to the US, creating a deadweight loss from the tariff.

(d) Show how the US tariff affects Saudi Arabian welfare,

The US import tariff causes world price (and hence Saudi price) to decrease from 100 to \( 100 - \frac{2}{5}t \). This causes Saudi consumption to rise, production to fall, and exports to decrease. The welfare impact is (see figure below)

\[
\Delta PS = -Area\left\{100, B, B', (100 - .4t)\right\} = -\left\{480t - .96t^2\right\}
\]

\[
\Delta CS = -Area\left\{100, A, A', (100 - .4t)\right\} = \left\{80t + .24t^2\right\}
\]

\[
\Delta W^{Sl} = \Delta PS + \Delta CS = -400t + 1.2t^2
\]

In terms of the figure below, the deadweight loss to Saudi Arabia is \( \text{Area}\left\{A', A, B, B'\right\} = \text{Rectangle 3} + \text{triangle 4 + triangle 5.} \)

If you compare the figures for the US and Saudi Arabia, you see that area “3” is a transfer from Saudi Arabia to the US because of lower export prices, while triangles 1 & 2 for the US, and triangles 4 & 5 for Saudi Arabia measure the overall inefficiency (or deadweight loss) due to the US policy. In terms of equations:

\[
\Delta W^{us} + \Delta W^{Sl} = \Delta W = \left(400t - 4.2t^2\right) + \left(-400t + 1.2t^2\right) = -3t^2 < 0, \quad t \neq 0
\]
Impact on Saudi Arabia of US import tariff

i. A Saudi export tariff, by lowering domestic prices in Saudi Arabia, would reduce the supply of exports and thus raise the world price of oil. Thus, just as the US gains from an import tariff, Saudi Arabia can gain from an export tariff. But note that, in each case, the benefits to the winner are smaller than the losses to the loser. Hence, it is possible that each country tries to act as a monopolist (a monopsonist in the case of the U.S., since it is a buyer), but by doing so both countries are worse off. However, neither country has the incentive to unilaterally end its tariff.

(c) How does the tariff affect world welfare?

As shown in part (d), it leads to a decline in world welfare because the volume of trade falls and a wedge is driven between production costs in the two countries, and also a wedge is driven between the value of oil to consumers in the two countries.

i. Why doesn’t the US unilaterally eliminate its tariff?

The simple point is that what is good for the world as a whole need not be good for the US without compensation. Thus, if the US unilaterally eliminates its tariff, the US loses even though Saudi Arabia gains even more. Without compensation of some sort, the US will be unwilling to lower tariffs. This is one reason why tariffs are often reduced as a result of international agreements rather than lowered unilaterally by countries (especially for larger countries. Smaller countries, with no ability to affect world prices, do not have the same incentive to maintain trade barriers).

2. Free Trade Area. Consider the computer industry; Mexico has following Supply and Demand:

\[ S = p^d; \quad D = 7000 - 3p^d \]

Mexico can import (identical) computers from the US at \( p^{us} = 1000 \) or from Japan at \( p^j = 800 \)
Mexico is small and does not affect world prices.

a) Initially, with $t = 300$ regardless of origin of imported computers:

Mexico imports from Japan; $P_{mex}^* = P^d + 300 = 1,100$

Hence: $Q_{mex}^* = p^d = 1100; \quad D = 7000 - 3p^d = 3700; \quad M = D - S = 2600$

b) Mexico forms FTA with US. Since there are no taxes on US computers, imports from US cost Mexican consumer 1000, those from Japan 1100. \textbf{Hence, imports come from US.}

$P^d = P^m = 1000; \quad S^m = 1000; \quad D^m = 4000; \quad M^m = 3000$

Mexican production falls, consumption increases, imports increase. The volume of trade increases by 400 (from 2600 to 3000) – this is trade creation; but all imports come from US rather than Japan – this is trade diversion. To see the welfare impact, consider this figure:

Consumers \textbf{gain}: Area \{1000,B*,B,1100\} = 100*3850 = 385,000

Producers \textbf{lose} Area \{1000,A*,A,1100\} = 100*1050 = 105,000

Government \textbf{loses} tariff revenue = 300*2600 = 780,000 (Area ABHJ)

\textbf{Net Loss} = 500,000

This net loss is the gain from trade creation (triangles \{A*,A,V\} and \{B,B*,W\}) minus the loss due to trade diversion (area \{V,W,H,J\}) - which reflects the higher costs paid for the original level of imports (2600 units) from the US rather than from Japan.

(c) If the tariff were originally $600 per unit (instead of $300 per unit), then before the FTA the price of Japanese imports in Mexico would be $1400, and all imports would come from Japan. So:
Pre-FTA: \( P^{\text{mex}} = 1400; \quad Q = 1400; \quad D = 2800; \quad \text{Imports} = 1400; \)
Tariff revenue = 840,000 (see figure below)

After the FTA, the tariff on US goods is eliminated and imports come from US. The post-FTA situation is the same as in (b):

Post-FTA \( P^{\text{mex}} = 1000; \quad Q = 1000; \quad D = 4000; \quad \text{Imports} = 3000 \)

Thus, the amount of trade creation is larger than in (b), and the amount of trade diversion is smaller. Hence, the net loss should be smaller (or the net gain larger). To measure it, see figure below:

Consumers gain: Area \{1000,B^*,T,1400\} = 1,360,000
Producers lose: Area \{1000,A^*,S,1400\} = 480,000
Government loses tariff revenue = 840,000 (Area STLM)
Net welfare gain = 40,000
This welfare gain equals the gains from trade creation (the triangles \{A^*,S,J\} and \{K,T,B^*\}) less the loss from trade diversion (area \{J,K,M,L\}) due to the fact higher priced imports from the US replace imports from Japan.

So, joining the FTA benefits Mexico in case (c), but not in (b). Explanation: trade creation in (c) is larger as imports increase from 1400 to 3000, whereas in (b) imports increase only by 400. In both cases trade diversion occurs, as imports from Japan that previously cost $800 to the country (remember the tariff revenue goes to the Mexican government) are diverted to imports from the US, which cost $1000. This trade diversion is larger in (b), where imports are originally 2,600 because of the lower tariffs, than in (c), where imports are only 1400. Moral: \textit{even if lowering all tariffs is good, it does not automatically follow that lowering some tariffs will improve welfare.}
3. Consider a small country (Thailand) with the following demand and supply curves for steel:

\[ \text{Supply} = Q_s = 6P_s; \quad \text{Demand} = 5000 - 4P_c \]

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: \( P_s^c = P_s^s \). Assume Thailand can import steel at a given world price of: \( P_s = 200 \) per ton of steel.

Suppose that the domestic production of steel in Thailand creates pollution, which damages the environment. Suppose the estimated (economic) cost of this pollution is 100 per ton of steel produced. This means that the marginal social cost of producing steel exceeds the marginal private cost of producing steel by 100. (Since the supply curve comes from equating marginal private cost to price, the marginal private cost (MPC) of producing steel is: \( Q_s = 6P_s \rightarrow MPC = \left( \frac{Q_s}{6} \right) \). Finally, assume the government has no domestic policy to redress the externality (pollution).

a) Suppose world price is 200. Since this is below the domestic autarky price, that means the country will import steel. There are the usual gains from trade (increased consumption because, starting from autarky, the value of steel exceeds the world price; the gains from decreased production, because private production costs exceed world price) and, in addition, there is the gain from the fact that the presence of pollution – for which there was no government policy – means that steel is overproduced domestically in autarky, and that reduced production reduces pollution damages. Thus, in this case, trade will be beneficial.

i. Calculate the gains or losses from trade in this setting.
The figure above shows the demand curve, the supply curve (marginal private cost) and the marginal social cost curve (MSC), which lies 100 units above the supply curve because of the pollution costs.

The autarky equilibrium is at E, with a price of 500, and output/consumption of 3000. This is not efficient because, at that output level, marginal social cost (point G) lies above the marginal value of the additional unit of output. Under autarky, the efficient equilibrium is at R, with a higher price and lower production/consumption.

Starting from E (no pollution tax), the movement from autarky to free trade at a price of 200 reduces domestic price and production, while increasing consumption.

Consumers gain area:  \{500,E,K,200\}
Producers lose area:  \{500,E,A,200\}
So, ignoring pollution, the gains by moving to free trade is the triangular area AEK, composed of the smaller triangles labeled 1 and 2. This is the usual argument of the gains from trade.

However, because of pollution, the lower output reduces pollution costs by 100*reduced output; this reduction in pollution costs is given by area of parallelogram \{A,A",G,E\}.

Hence, the total gains from free trade are area \{EHK\} or triangle 2 – the gain due to increased consumption; plus area \{A,A",G,H\} – the gains due to reduced production (i.e., it is the savings in social cost – the area under the MSC curve between 1200 and 3000, less the cost of importing this quantity – area of rectangle \{1200,A,H,3000\}. The gains from trade are larger than in the case where there are no externalities.

Calculating the gains:
\[\Delta CS = \frac{1}{2} \cdot 300 \cdot [3000 + 4200] = 1,080,000\]
\[\Delta PS = -\frac{1}{2} \cdot 300 \cdot [1200 + 3000] = -630,000\]
Reduction in pollution costs:  \(100 \cdot (1800) = 180,000\)
Total Welfare Gain = 1,080,000 - 630,000 + 180,000 = 630,000

i. The best policy to attack the market failure is to “internalize the externality” – i.e., make firms take in to account the costs they impose on others. This means taxing their output based on pollution emissions (and damages done), or for this specific case a 100 tax on steel output.

ii. What to do if only trade policy can be used? In this case, since the problem is firms produce too much (even at the lower world price, the marginal social cost of producing steel is above the cost of getting steel from the world market), then the optimal policy is to subsidize imports, reducing domestic price, thus domestic output and pollution. {You do not have to do a calculation here but I will}. If the subsidy is \(s\), then domestic price is \((200-s)\), domestic production is \(6P^d = 1200-6s\); domestic consumption is \(5000 - 4P^d = 4200+4s\), and imports are \(3000+10s\). The changes in surplus are and in pollution costs due to the subsidy (as compared to free trade)

\[\Delta PS = \frac{1}{2} \cdot (-s) \cdot (1200+1200+6(-s)) = -1200s + 3s^2\]
\[\Delta CS = \frac{1}{2} \cdot s \cdot (4200+4200+4s) = 4200s + 2s^2\]
\( TR = (-s)M = (-s)(3000 + 10s) = -3000s - 10s^2 \) is tariff revenue (which is negative)

\[ \text{Reduction Pollution Cost} = 100 \cdot (-\Delta Q) = 100 \cdot (-6s) = -600s \]

Thus, the overall welfare change is:

\[ \Delta W = \Delta CS + \Delta PS + TR - \text{Reduction Pollution Cost} = -5s^2 + 600s \]

\[ \frac{dW}{ds} = 600 - 10s = 0 \rightarrow s^* = 60 \]

So, the second best policy is an import subsidy that reduces domestic price to 140 and lowers domestic output. The best solution is a tax of 100 on steel output (or pollution).

b) If the world price is 550, above the autarky price (without a pollution tax), the country will export, rather than import, steel and thus trade will increase domestic production and pollution. Hence, it is quite possible that for this case trade reduces welfare. First, note that while the autarky price is 500, the efficient autarky price (point R in the figure) is found from imposing a tax of 100 on production so:

\[ S = D \rightarrow 6 (P^C - 100) = 5000 - 4P^C \rightarrow 10P^C = 560 \rightarrow P^C = 560; \quad P^* = P^C - 100 = 460 \]

Thus, if a pollution tax were imposed on firms, the country should import, rather than export, steel.

i. Due to trade, domestic price increases from 500 to 550, domestic consumption falls from 3000 to 2800, and domestic production increases from 3000 to 3300. The welfare effects are as follows:
Thus, trade lowers welfare. Overall, the gain is area \{A,E,B\} less area \{E,J,K,B\}

\[ \Delta W = -145,000 + 157,500 - 30,000 = -17,500 \]

ii. As in part (a), since the market failure is that marginal private production costs are lower than marginal social costs, the optimal policy is to tax pollution, which in this case is synonymous with a tax of 100 on production of steel. If that were done the autarky price would be 560, and the country would — under free trade — import steel rather than export steel.

iii. If only trade policy is possible, then the goal of the policy would be to reduce domestic production below that which would occur under free trade. Since, under free trade without pollution taxes, the country would export steel while — under the optimal policy it would import steel — clearly banning steel exports is desirable.

Furthermore, if feasible, it is actually optimal to import some steel, which would of course require significant import subsidies. You are not expected to calculate that subsidy, but you could in the following way.

We can express producer surplus, consumer surplus and pollution costs as a function of the domestic price. Since we can also calculate production and demand, we can determine imports as a function of the domestic price. Having done that, we can calculate the government tax revenue or cost as a function of the domestic price, and using all these terms we can calculate the optimal domestic price.

From the demand and supply curves:

\begin{align*}
\text{(CS) Consumer Surplus} & = 2 \cdot \left( 1250 - P^d \right)^2 \\
\text{(PS) Producer Surplus} & = 3 \cdot \left( P^d \right)^2 \\
\text{Pollution Costs} & = 6P^d \cdot z; \quad z = 100 \\
\text{Imports} & = 5000 - 10P^d \quad \text{(exports, if negative)} \\
\text{(GR) Govt. Revenue (costs, if negative)} & = \left( P^d - P^w \right) (D - Q) = \left( P^d - 550 \right) \left( 5000 - 10P^d \right) \\
\text{Welfare} & = \text{CS} + \text{PS} - \text{Pollution Cost} + \text{GR}: \\
W & = 2 \cdot \left( 1250 - P^d \right)^2 + 3 \cdot \left( P^d \right)^2 + \left( P^d - 550 \right) \left( 5000 - 10P^d \right) - 6zP^d \\
\frac{dW}{dP^d} & = -4 \left( 1250 - P^d \right) + 6P^d + \left( 5000 - 10P^d \right) - 10\left( P^d - 550 \right) - 6z = 10\left( 550 - P^d \right) - 6z
\end{align*}

Note if \( z = 0 \) (no pollution) free trade is optimal — i.e., \( P^d = P^w = 550 \). For \( z = 100 \),
\[
\frac{dW}{dP^d} = 4900 - 10P^d = 0 \rightarrow P^d = 490.
\]
Thus, for this case, the optimal trade policy – given that no other policy is feasible – is a ban on exports AND an import subsidy of \(60 = P^w - 490\).

Note that you must have the export ban otherwise people will buy at \(490\) on the domestic market and resell internationally. If you can’t have an import subsidy, then you should just ban exports.