Etude4 - Desert Crossing

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1. Using the vehicle without refuelling, how far into the desert can you safely go?

Beginning with a reference to the etude 4 document. The vehicle can carry a maximum load of 140L of fuel. This includes the 60L vehicle fuel tank and the 4 * 20L additional fuel cans the vehicle can carry as a maximum payload. The vehicle in this assessment specifies a travel distance of 12km per litre of fuel.
To cross the desert of 2413km you will exhaust 2413km/12 = 201.084L of fuel. This is over the maximum fuel the vehicle can carry so we must begin stockpiling fuel along the way with multiple fuel stockpile return trips, each time leaving some amount of fuel cans behind

With a maximum capacity of 140L fuel, this gives the vehicle a maximum travel range of:: 1680km

12km * 140L = 1680km.

The distance to return from safe travel is the (maximum travel distance maximum / 2).
With regards to more efficient means of conserving fuel to cross the desert. This distance into the desert may be a very important point to remember for a fuel position.

This shows the vehicle can safely travel and return a maximum distance of 1680/2 = 840km into the desert. At 840km exactly half the vehicle's fuel has been consumed.

2. Describe a procedure whereby you could cross the desert in the vehicle

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Origin 2413km

To travel across the desert in its entirety, fuel positions are needed positioned at different points of travel distance. This process however does come at the expense of great amounts of fuel. Regardless of the inefficiency of travelling across the desert. We begin by placing fuel at 720km into the desert as the first fuel point.

Across the desert three fuel positions are needed between intervals of 720km. One interval at 720km, the second 1440km, the third 2160km.

Justification:

- Because these three fuel positions in the desert are equidistant from each other. Given that fuel conservation is not a priority. To perform the calculations to determine the amount of fuel and distance travelled to reach across the end of the desert will be much easier. This scalar fuel position system could also be helpful in determining how much fuel and distance travelled will be needed to make a return trip across the desert.

Origin 720km 1440km 2160km 2413km

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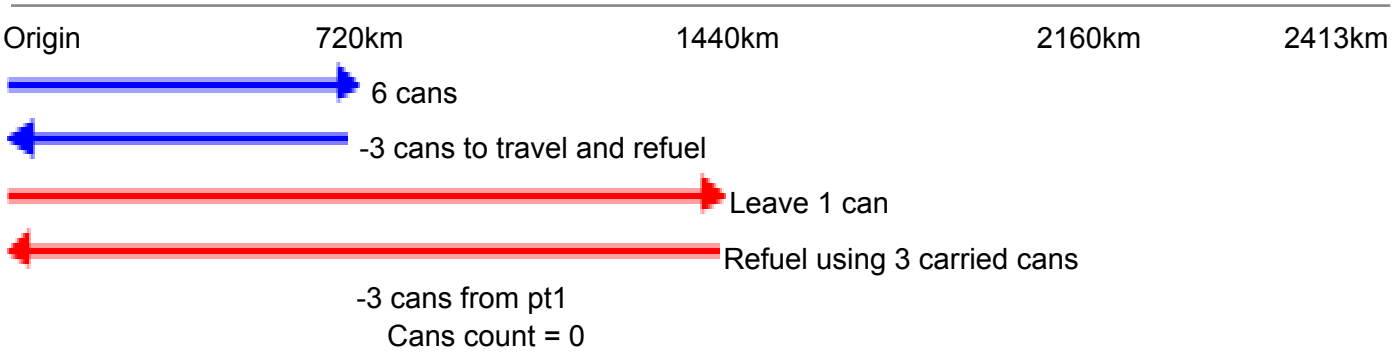
Phase #1:
Begin with travelling 720km into the desert and leaving 1 fuel can at the first fuel position at 720km. Repeat this single step six times, Leaving 6 cans in total at 720km.
Calculations:

Distance	Fuel
1440 * 6 = 8640km	120L* 6 = 720L
Total Distance: 8640km	Total Fuel: 720L

Phase#2:

Using the 6 cans left at 720km. This will allow the truck to reach fuel position two at 1440km, the truck can then leave 1 cans behind at this fuel position. To do this however an additional 120L of fuel is required from the origin point of travel before crossing the desert.



Calculations:

Distance	Fuel
1440km * 2 = 2880km	(6*20) + (6*20) = 240L
Total Distance:	Total Fuel:
8640km + 2880km	720L+240L
= 11520km	= 960L

Phase#3:

Two more cans need to be placed at fuel position two to reach fuel position three at 2160km. With an additional 3 cans at fuel position two for the return trip. Therefore to leave 6 cans at fuel position two, Phase 1 needs to be repeated 6 times per each of phase 2 execution. Once this is completed execute phase 1 again an additional 6 times for fuel needed for fuel position three return trips.

Calculations:

Distance	Fuel
11520km * 6 = 69120km	960L * 6 = 5760L
Refuelling Pt1 (720km)	
69120km + 8640km	5760L + 720L
Distance Total:	Fuel Total:
77760km	6480L

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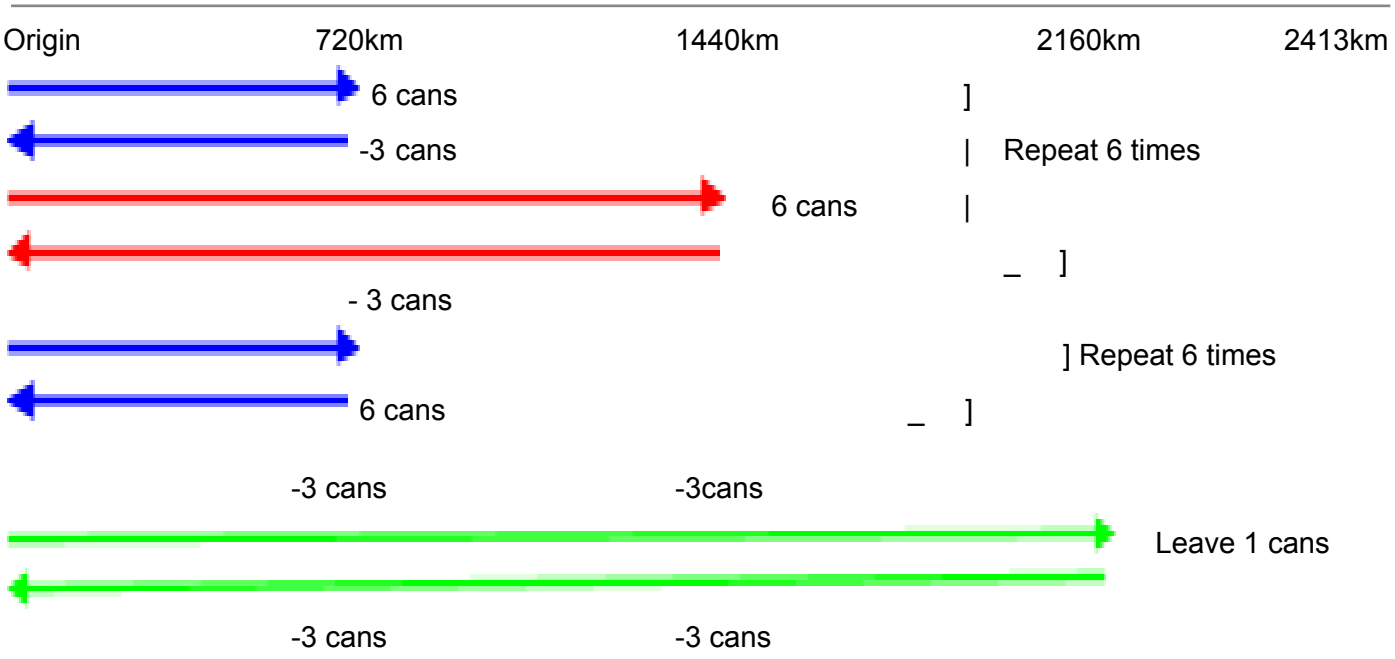
Scalar graph
As a helpful tip for recollection, to reach the following fuel position, 6 trips to the preceding positions are required.

Pt1	pt2	pt3
1		
6	1	
36	6	1



At this point in the process of getting across the desert. One more execution of phase 3 is required. As the remaining distance to the deserts ending is:

2413 - 2160 = 253.

To execute phase Three of driving across the desert. 6 additional cans of fuel or 120L of fuel is required to reach point 3 including the consumption of 6 cans of fuel positioned at both 720km and 1440km.

Calculations:

Distance to pt3	Fuel to pt3
2160km * 2	(6*20L) + (6*20L) + (6*20L)
4320km	360L
Distance Total:	Fuel Total:
77760km+4320km	6480L+360L
= 82080km	= 6840L

Multiply by 2 to leave 2 cans of fuel at pt3 (2160km)

Distance:	Fuel:
164160km	13680L

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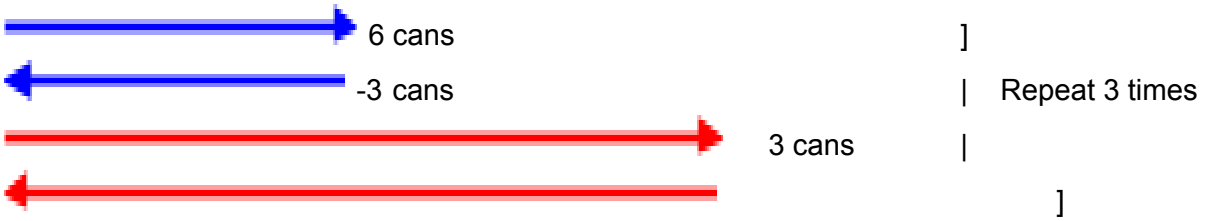
To execute phase 3 twice. The previous phases must be performed as shown previously. Rounding up to the nearest whole fuel canister. Two cans of fuel at 2160km fuel position will allow the truck to reach its destination across the desert.

Phase#4:

Origin 720km 1440km 2160km 2413km
2 cans

Next before the final departure and rotation of fuel drops. Three cans must be placed at
Fuel position 2. This will allow the truck to travel across the desert in one stretch until fuel has nearly run out.



] Repeat 3 times]

With 2 cans placed at fuel position three, three fuel cans placed at fuel position 2 and three fuel cans placed at fuel position 3. The truck can now make a final trip across the desert carrying only a full fuel tank.

164160km 13680L

Using the values from the previous calculations for travel to pt1(720km) and pt2(1440km)

11520km * 3, 960L * 3 = 34560km, 2880L pt2
1440km * 3, 120L * 3 = 4320km, 360L pt1

Sum:
Distance: Fuel:
164160 + 11520 = 1440, 13680 + 2880 + 360
= 203040km = 16920L

Phase # 5
Final trip: Using a full fuel tank.

Origin 720km 1440km 2160km 2413km
3 cans 3 cansiers 2 cans

Fuel out Refuel Tank Refuel Tank reached
Use cans

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Final Trip Calculations:

203040km	16920L
+2413km	(3* 20) + (3* 20) + (2* 20) = 160L

Total Distance = 205453km Total Fuel = 1708

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3. Describe a procedure whereby you could cross the desert and return in the vehicle.

For this voyage across the desert and return, the previous layout of fuel positions and travel can be reused. Refer to the previous briefing on the fuel positions if needed.

NOTE: Much of the same processes are done to successfully return from across the desert.

Layout:

Origin 720km 1440km 2160km 2413km

Every previous phase of the Latter question can be executed again up until phase#3 of question 2.

Recall:

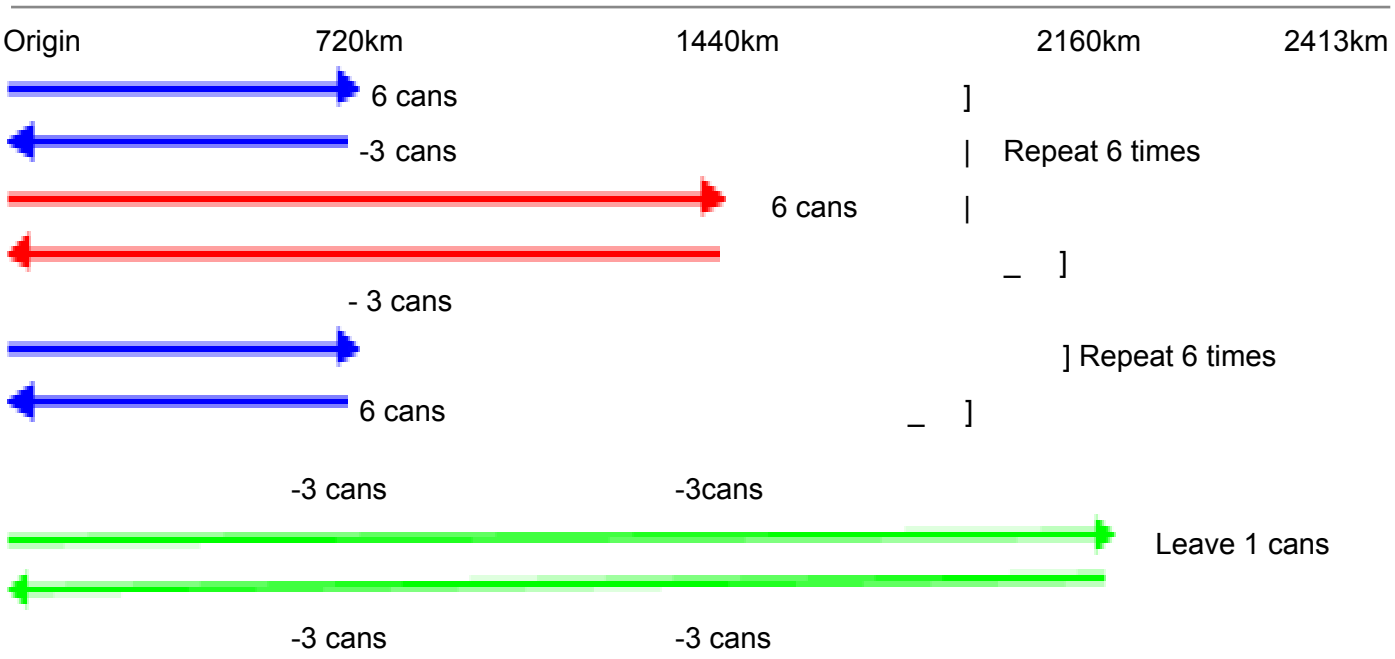
Phase#3:

Two more cans need to be placed at fuel position two to reach fuel position three at 2160km. With an additional 3 cans at fuel position two for the return trip. Therefore to leave 6 cans at fuel position two, Phase 1 needs to be repeated 6 times per each of phase 2 execution. Once this is completed execute phase 1 again an additional 6 times for fuel needed for fuel position three return trips.

Scalar graph

As a helpful tip for recollection, to reach the following fuel position, 6 trips to the preceding positions are required.

Pt1	pt2	pt3
1		
6	1	
36	6	1



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This phase needs to be executed again so that a total of three cans of fuel can be left at the third fuel position.

After executing this third phase of step Question 2, the fuel at the previous two fuel stops will be zero due to the trip to position 3 and the return trip will reduce all the fuel cans to 0.

Calculations:
= 82080km = 6840L
Multiply by 3 to leave 3 cans of fuel at pt3 (2160km)
Distance: Fuel:
246260km 205020L

Thus far the fuel storage will look like this:

Origin 720km 1440km 2160km 2413km
0 cans 0 cans 3 cans

Phase # 4

For the truck to make the travel and return from the end of the desert. 6 cans of fuel need to be placed at each pt2(1440km) and pt1(720km). Therefore Phase one and two of question two needs to be executed again to replenish the fuel at these positions.

A total of six additional cans need to be left at the first fuel position without them having to be reused for fuel replenishment to reach fuel position 2.

Origin 720km 1440km 2160km 2413km

The above diagram is a repeat of Question 2 Phase#1.

With the addition of 6 extra cans at this point to make 12 int total. Continue to drop off cans at fuel position 2 by using the six additional cans at fuel position 1. This leads to a repetition of Question two phase#2.

Calculations
Distance: Fuel:
246260km 205020L

Phase 1 Repeat
Added Distance: Added Fuel:
1440 * 6 = 8640km 120L* 6 = 720L
Distance: 8640km Total Fuel: 720L

Total Distance Total Fuel
254900km 205740L

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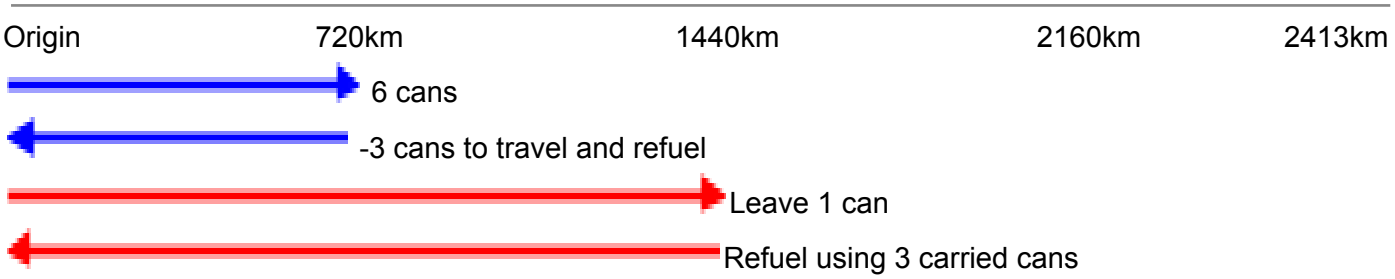
Using the 6 cans left at fuel position 1 at 720km. This will allow the truck to reach fuel position two at 1440km, the truck can then leave 1 cans behind at this fuel position.



This phase needs to be executed 6 times so that there are a total of 6 cans of fuel left at fuel position 2 at 1440 km.

Calculations:

Distance	Fuel
254900km	205740L

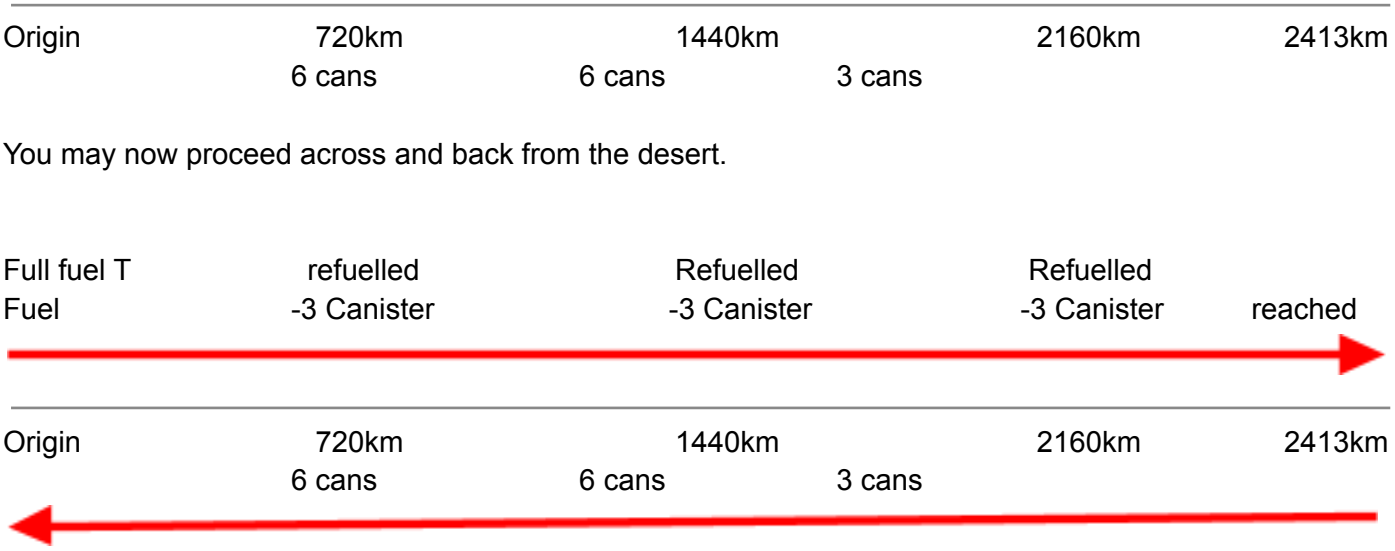
Phase 2 Repeat 6 times

Added Distance:	Total Fuel:
8640km + 2880km	720L+240L
= 11520km	= 960L
11520km * 6 = 69120km	960L * 6 = 5760L

Total Distance:	Total Fuel:
324020km	211500L

Final Stretch:

The fuel left at each position should match the description in the below figure: The fuel required to travel from the origin to the first position is 60L or a full fuel tank.



You may now proceed across and back from the desert.

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Reached back	-3 Canister Total can = 0	-3 Canister Total can = 0	Use 4 can cargo

Final travel Calculation:

Current Distance and Fuel Consumption

Total Distance:	Total Fuel:
324020 km	211500L
+4826km	Tank:60L + pt1:240L + pt2240L + pt3:120L

Total Distance:	Fuel:
328846km	212160L

Finalised Procedure for Q4:

4. Describe a procedure whereby you could cross the desert in the vehicle using the minimum amount of fuel.

The first thing we discovered when trying to solve this problem is that if we have a full stock of fuel 733km into the desert then we will be able to make it all the way across to the end of the desert.
This is because we can travel a total of 1680km on a full stock of fuel and 2413 - 1680 = 733.

We then knew that to have a full tank at point 733km, we would need to replenish the 733km of fuel we used to get there, therefore we needed to drop off 733km worth of fuel(61.0833L) at point 733km.

We then discovered that if we left from the base with a full stock then travelled to point 733km and left 733km worth of fuel there then made our way back, we would be stranded 519km from the base with no fuel.
Therefore we needed to leave a fuel position at point 519km with 519km worth of fuel (43.25L).
However, we discovered if we left the same amount of fuel but at point 259.5km (half of 519km) and refueled at this point with half of the stored fuel on the way into the desert then carried on and used the rest of the fuel to get back, we could lessen the amount of fuel used, therefore, using a total of 366.5L of fuel.

Step One:
Travel 259.5km into the desert and leave 43.25L of fuel(519km worth of fuel) Travel back to base (519km travelled: 43.25L of fuel used)

259.5km

leave 43.25L of Fuel (2 and a bit cans)

(Travelled 519km: used 43.25L of fuel)

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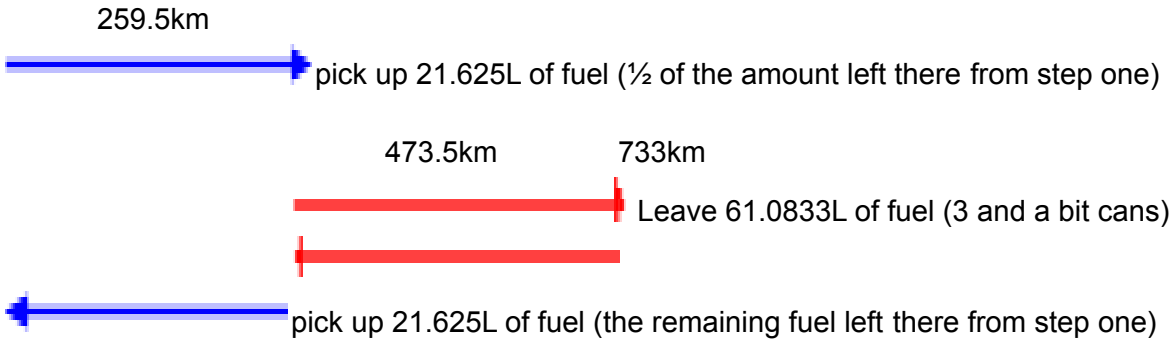
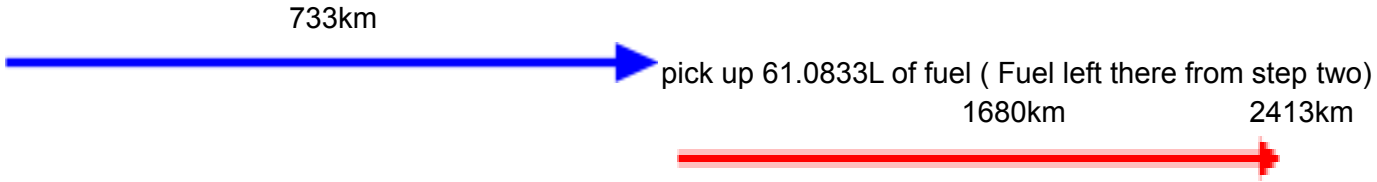
Step Two:
Travel 259.5Km into desert and pick up 21.625L(half of the fuel left there from step one) of fuel(259.5Km worth of fuel) then travel a further 473.5Km (so you are 733km into the desert) leave 61.0833L of fuel, travel back 473.5km and pick up the 21.625L left behind, travel back to the base. (1,466Km travelled: 122.166667L used:)



(Travelled 1,466Km: Used 122.166667L of fuel)

Step 3:
Full up, travel 733km into desert and full up with the 61.0833L of fuel left. Travel the last 1680Km to the end of the desert. (2413km travelled: 201.083333L used)



(Travelled 2413km: Used 201.083333L)

Amount of litres used throughout the entire procedure:
43.25 + 122.166667 + 201.08333 = 366.499997L

After this procedure, the vehicle will have consumed a total of 366.499997L of fuel and will have made it to the other side of the desert.

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5. Describe a procedure whereby you could cross the desert and return in the vehicle using the minimum amount of fuel.

Step 1: At the base of the desert, fill the car's tank with 40 litres of fuel and load the car with 4 of the 20 litre cans. Using half of the fuel in the car's tank (20L), we travel 240km into the desert, drop off the 4 cans, then use the remaining 20 litres of fuel to drive back to base. We repeat this step for a total of 4 times. This therefore leaves us with 16 cans of fuel (which is equal to 320 litres) located at the 240km position. (consumed 160 litres total)

Step 2: At the base of the desert, we now fill the car's tank with 60 litres of fuel (a full tank) instead of 40 litres, and we load the car with 4 of the 20 litre cans. We then travel 240km into the desert, use one of the cans to refuel the car's tank, then continue driving until we reach 480km deep into the desert. At 480km, we drop off 4 cans of fuel, and then we drive back to base. We repeat this step for a total of 4 times. This therefore leaves us with 12 cans of fuel (which is equal to 240 litres) at the 240km position and 16 cans of fuel (which is equal to 320 litres) at the 480km position. (consumed 320 litres total)

Step 3: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 240km into the desert, use one of the cans to refuel the car's tank at that point, then continue driving until we reach 480km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then travel until we reach 720km deep into the desert, and drop off 4 cans of fuel. On our way back to base camp from the 720km position, we stop at the 240km position and use another can of fuel to refuel the car's tank so we can make it back to base. We repeat this step for a total of 2 times. This therefore leaves us with 8 cans of fuel (which is equal to 160 litres) at the 240km position, 14 cans of fuel at the 480km position and 8 cans of fuel at the 720km position. (consumed 240 litres total)

Step 4: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 240km into the desert, use one of the cans to refuel the car's tank at that point, then continue driving until we reach 480km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then travel until we reach 720km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then continue driving until we reach 960km deep into the desert and drop off the 4 cans of fuel. On our way back to base camp from the 960km position, we stop at the 480km position and use another can of fuel, and then we stop at the 240km position and use another can of fuel to make it back to base. This therefore leaves us with 6 cans of fuel at the 240km position, 12 cans of fuel at the 480km position, 7 cans of fuel at the 720km position and 4 cans of fuel at the 960km position. (consumed 160 litres total)

Step 5: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 240km into the desert, use one of the cans to refuel the car's tank at that point, then continue driving until we reach 480km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then travel until we reach 720km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then continue driving until we reach 960km deep into the desert and drop off the 4 cans of fuel. On our way back to base camp from the 960km position, we stop at the 480km position and we use 2 cans of fuel to refuel the car's tank in order to make it back to base. This therefore leaves us with 5 cans of fuel at the 240km position, 9 cans of fuel at the 480km position, 6 cans of fuel at the 720km position and 8 cans of fuel at the 960km position. (consumed 160 litres total)

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Step 6: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 480km into the desert, and we use 2 cans of fuel to refuel the car's tank at that point, then we continue driving until we reach 720km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We continue to travel until we reach 1200km deep into the desert and we drop off 4 cans of fuel. On our way back to base camp from the 1200km position, we stop at the 960km position and we use 2 cans of fuel to refuel the car's tank, we then stop at the 480km position and use another 2 cans of fuel to refuel the car's tank in order to make it back to base. This therefore leaves us with 5 cans of fuel at the 240km position, 5 cans of fuel at the 480km position, 5 cans of fuel at the 720km position, 6 cans of fuel at the 960km position and 4 cans of fuel at the 1200km position. (consumed 200 litres total)

Step 7: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 240km into the desert, use one of the cans to refuel the car's tank at that point, then continue driving until we reach 480km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then travel until we reach 720km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then continue driving until we reach 960km deep into the desert and use one of the cans to refuel the car's tank at that point. We then continue travelling until we reach 1200km deep into the desert and use one can of fuel to refuel the car's tank. We then continue to travel until we reach 1440km deep into the desert, and we drop off the 4 cans of fuel. On our way back to base camp from the 1440km position, we stop at the 960km position and use 2 cans of fuel to refuel the car's tank. We then stop at the 480km position and use one can of fuel to refuel the car's tank. We then stop at the 240km position and use one can of fuel to refuel the car's tank in order to make it back to base. This therefore leaves us with 3 cans of fuel at the 240km position, 3 cans of fuel at the 480km position, 4 cans of fuel at the 720km position, 3 cans of fuel at the 960km position, 3 cans of fuel at the 1200km position and 4 cans of fuel at the 1440km position. (consumed 240 litres total)

Step 8: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 240km into the desert, use one of the cans to refuel the car's tank at that point, then continue driving until we reach 480km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then travel until we reach 720km deep into the desert, and we use one of the cans to refuel the car's tank at that point. We then continue driving until we reach 960km deep into the desert and use one of the cans to refuel the car's tank at that point. We then continue travelling until we reach 1200km deep into the desert and use one can of fuel to refuel the car's tank. We then continue to travel until we reach 1440km deep into the desert, and we drop off the 4 cans of fuel. On our way back to base camp from the 1440km position, we stop at the 1200km position and use one can of fuel to refuel the car's tank. We then stop at the 720km position and use 2 cans of fuel to refuel the car's tank. We then stop at the 240km position and use one can of fuel to refuel the car's tank in order to make it back to base. This therefore leaves us with 1 can of fuel at the 240km position, 2 cans of fuel at the 480km position, 1 can of fuel at the 720km position, 2 cans of fuel at the 960km position, 1 can of fuel at the 1200km position and 8 cans of fuel at the 1440km position. (consumed 260 litres total)

Step 9: At the base of the desert, we fill the car's tank with 60 litres of fuel (a full tank) and we load the car with 4 of the 20 litre cans. We then travel 480km deep into the desert and we use one can of fuel to refuel the car's tank at that point. We then continue to drive until we reach 960km deep into the desert, and we use one can of fuel to refuel the car's tank. We also use one can of fuel that we've been carrying to refuel the car's tank (therefore currently carrying 3 cans of fuel). Then we continue to travel until we reach 1440km deep into the desert, and we use one can of fuel to refuel the car's tank at that point. And now we take one can from the 1440km position and load it into the car (therefore currently carrying a max of 4 cans of fuel again). We then travel until we reach 1573km deep into the desert and drop off 3 cans (therefore leaving us with one can left loaded in the car). This therefore leaves us with 1 can of fuel at positions 240km, 480km, 720km, 960km, and 1200km; 6 cans of fuel at the 1440km position and 3 cans of fuel at the

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1573km position. (consumed 131.083 litres total) (therefore have 8.917L left in the car's tank, which is equal to ~107.04km range, therefore 1573-108 = 1466, this is for the next step below).

Step 10: On our way back to position 1440km from the 1573km position, we need to use the one can that we've been carrying in the car to get us back to the 1440km position. This means that when we reach the 1466km position (using the remaining fuel in the car's tank), we refuel the car's tank using that one can to get us back to 1440km. The car now has 214km worth of fuel remaining (0.89 of a tank, or 17.833L). Now at position 1440km, we load the car with 3 cans of fuel and we use an additional 2 cans of fuel to refuel the car's tank. The car's tank now has 57.833L in it. We then drive to the 1573km position (which is 133km away), using 11.0833L. This means that we have 46.75L of fuel remaining in the car's tank. We can use one can from the 1573km position to put into the car's tank. This will fill the car tank up, and have 6.75L remaining. We load 1 full can from this location into the car so the car is carrying a total of 4 cans again. This therefore leaves us with 1 can of fuel at positions 240km, 480km, 720km, 960km, 1200km, 1440km and 1573km. (consumed 22.1653 litres total)

Step 11: We leave position 1573km with a full tank and 4 full cans. We continue to travel until we reach 2293km deep into the desert only using the car's fuel tank. We refuel the car's tank with 3 cans at the 2293km position. From there we keep travelling the remaining 120km to cross the desert and 600km backwards before needing to refuel. We stop at the 1813km position and refuel the car's tank using our last can of fuel. With this we travel another 240km to arrive back at the 1573km position. We then put the full can plus the 6.25L can into the fuel tank. This means we have 26.75L in our fuel tank. We drive back to the 1440km position, using 11.0833 L. When we arrive at the 1440km position, we have 15.66L in the fuel tank. We put the last can at this location into the fuel tank. We then drive back to 1200km and put that fuel can in the tank. We then drive back to 960km and put that fuel can in the tank. We then drive back to 720km and put that fuel can in the tank. We then drive back to 480km and put that fuel can in the tank. We then drive back to 240km and put that fuel can in the tank. We have successfully crossed and returned from the desert, wasting a total of 15.66L.
(consumed 251.083 litres total)

TOTAL SUM CONSUMED = 2144.3313 litres