Module 11 – EOQ

Exploratory Data Analysis
In this section, you should perform some data analysis on the data provided to you. Please format your findings in a visually pleasing way and please be sure to include these cuts:

- *Make line graphs showing the following data over time:*
  - *Sales*
  - *Unit Purchase Cost*
  - *Fixed Order Cost*
- *Use a forecast method to determine annual demand for 2025 to use for our model*
  - ***Naïve***
  - *Moving Average / Weighted Moving Average*
  - *Linear Regression*
  - *Exponential Smoothing*
- *For costs, use a similar/different method. Otherwise, a simple overall average is fine.*

Model Formulation
Write the formulation of the model into here prior to implementing it in your Excel model. Be explicit with the definition of the decision variables, objective function, and constraints. Please restate the variables in the algorithm (i.e. D = Annual Demand)

Decision Variable:
Order Quantity: Cell I9
(only one cell for this model)

Objective Function:
Sum(I11:I13)
Sum of Purchasing cost, Cost of Ordering, and Inventory Cost, giving us the <u>Total Cost</u>

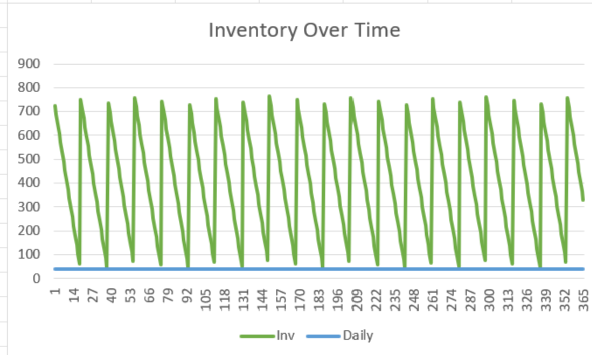
Constraints:
non-negativity constraint:
I9 >= 0

Model Optimized for Minimizing Costs with Optimal Order Quantity
Implement your formulation into Excel and be sure to make it neat. This section should include:

- *A screenshot of your optimized final model (formatted nicely, of course)*
- *A text explanation of what your model is recommending*
- *Make a "sawtooth chart" for 2025, see below for reference. Assume you start with year with your EOQ Quantity like it has below*

date	Inv	Daily	Ending	Replenishment	
1/1/2025	725	38.95068	686	FALSE	0
1/2/2025	686	38.95068	647	FALSE	0
1/3/2025	647	38.95068	608	FALSE	0
1/4/2025	608	38.95068	569	FALSE	0
1/5/2025	569	38.95068	531	FALSE	0
1/6/2025	531	38.95068	492	FALSE	0
1/7/2025	492	38.95068	453	FALSE	0
1/8/2025	453	38.95068	414	FALSE	0
1/9/2025	414	38.95068	375	FALSE	0
1/10/2025	375	38.95068	336	FALSE	0
1/11/2025	336	38.95068	297	FALSE	0
1/12/2025	297	38.95068	258	FALSE	0
1/13/2025	258	38.95068	219	FALSE	0
1/14/2025	219	38.95068	180	FALSE	0
1/15/2025	180	38.95068	141	FALSE	0
1/16/2025	141	38.95068	102	FALSE	0
1/17/2025	102	38.95068	63	FALSE	0
1/18/2025	63	38.95068	24	TRUE	725.3014
1/19/2025	749	38.95068	711	FALSE	0
1/20/2025	711	38.95068	672	FALSE	0

D	**Annual Demand**	**14,217**	**D/Q**	19.60151
C	**Cost per Unit**	**$ 52.42**		
S	**Cost per Order**	**$175**		
i	**Holding Cost**	**18%**		
Q	**Order Quantity**	725.3013739		
	Purchasing Cost	$745,240		
	Cost of Ordering	$3,422		
	Inventory Cost	$3,422		
	Total Cost	**$752,084**		



The model above recommends an inventory management model with the proposed order quantity of approximately 725 units, based on the Economic Order Quantity (EOQ) framework. This is done to minimize the total annual inventory management cost with the information we were given, with some calculated values. For my data, we observe an annual demand of 14,217 units, a unit cost of $52.42, an ordering cost of $175 per order, and a holding cost rate of 18% of the unit cost. With this, the model calculates an optimal order quantity of 725 units, and my "sawtooth chart" to the right demonstrates the trend of the two computed columns, Inventory and Daily. We can see that inventory decreases by a steady ≈39 units per day, and when it drops to a level that is below 78 (two days of inventory usage) an order of 725 units is replenished, preventing stockouts. With this minimized cost, found by solver, we have the *optimized* total cost value (with our given information) and we solved for the corresponding order quantity.

Model with Stipulation

Please copy the tab of your original model before continuing with the next part to avoid messing up your original solution.

Implement the below EOQ extension, EOQ with planned backorders. We have added 2 new variables: A = shortage cost & b = planned back orders. Restate the previous variables with these new ones please. Note, you'll need to solve for both Q and b* here to get the optimal solution. You should start Q out as the EOQ from the previous section and b as 0. Also, note that this algorithm does not include `D * C` as it's not relevant to this analysis* ✓

$$\text{Total Relevant Cost} = \frac{D}{Q}S + \frac{(Q-b)^2}{2Q}C_i + \frac{b^2}{2Q}A$$

Annual Demand (D)- 14,217
Cost per unit (C)- $52.42
Cost per order (O)- $175
Holding Cost rate (i)- 18%   (Ci)= 9.4356
Order Quantity (Q)- 725.30

$Q = \sqrt{\dfrac{2Ds\,(Ci + A)}{Ci\,A}}$

$2Ds\,(Ci + A) = 4{,}975{,}950(30.4356)$

$\approx 151{,}460{,}810.34$

$Q = \sqrt{764{,}392.42}$

$\dfrac{2Ds\,(Ci + A)}{Ci\,A} = \dfrac{151{,}460{,}810.34}{198.1476}$

$\rightarrow 764{,}392.42$

$Q = 874.29$

$b = \sqrt{\dfrac{2Ds}{A(Ci + A)}}$

$A(Ci + A) = 21 \cdot 30.4356 \approx 639.1476$

$b = \sqrt{7{,}783.90} = 88.23$

$\dfrac{2Ds}{A(Ci + A)} = \dfrac{4{,}975{,}950}{639.1476} = 7{,}783.90$

$b \approx 88$

Ordering Cost – 2,846.85

Holding Cost – 3,336.65

Storage Cost – 93.03

Total = 6,275.53

$\dfrac{D}{Q}s = 3{,}422$ (from original)

$\dfrac{(Q-b)^2}{2Q}\,Ci = \dfrac{(725.3031739 - 0)}{2 \cdot 725.3031739} \cdot 9.4356$

Total Relevant Cost
= $6,844

$\approx 3{,}422$ $\dfrac{b^2}{2Q}A = 0$

When A=21

$Q = 874$ units $b = 88$ units

The new cost (6844) is indeed lower, confirming that allowing planned backorders reduces the total relevant cost

Lastly, do the following:

- *Explain why you may include planned backorders (i.e. plan to accept purchases when out-of-stock, such that some customers will wait for their purchase). Please think critically prior to doing any searches for why*
- *Make a similar "sawtooth chart" with the results here. Note, it will be very similar as before, but inventory will go below 0 before replenishing*

A business might include planned backorders to reduce holding costs, lower the frequency of orders, and optimize total inventory costs, provided that customers are willing to wait. The shortage cost is manageable, and the supply chain can support timely replenishment. This strategy works best for stable demand, reliable supply chains, and products where customer loyalty or lack of alternatives/substitutes mitigates the risk of lost sales. In our model, the cost savings from reduced holding costs outweigh the shortage costs, making planned backorders a financially sound decision. I think.