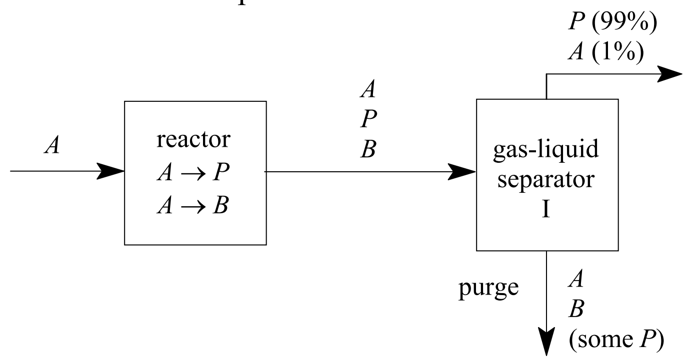
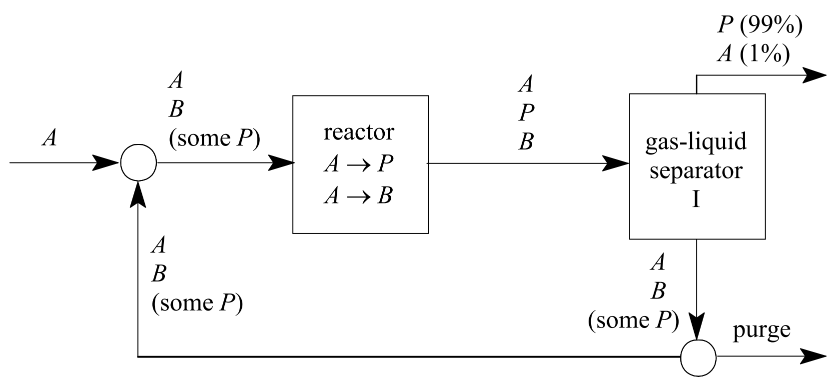
Design Competition Overview - 2025

Produce P by the reaction $A \rightarrow P$, which is accompanied by a parallel reaction, $A \rightarrow B$. Both reactions are irreversible. Both reactions are incomplete; the reactor effluent contains reactant A, product P and worthless by-product B.

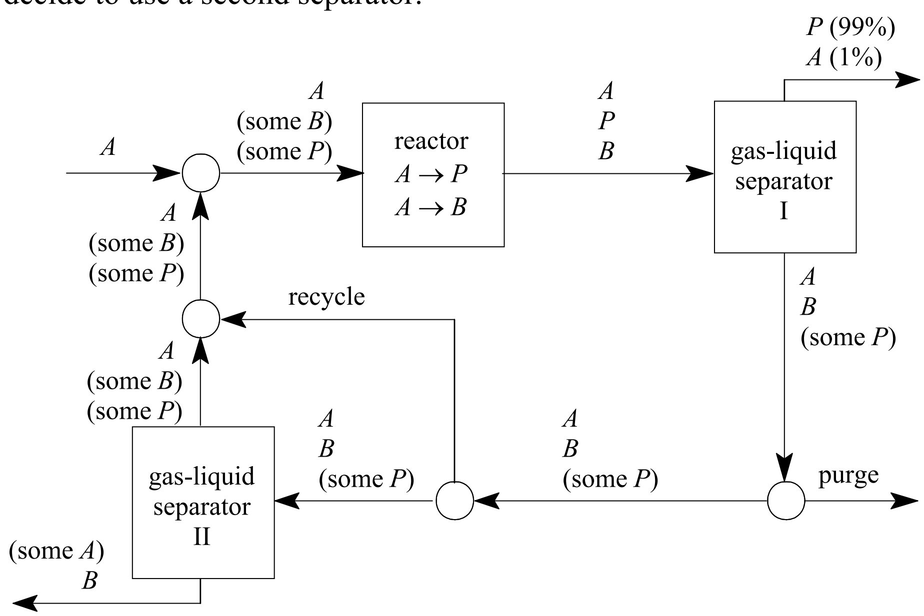
The simplest design is a reactor and a separator.



You may decide to recycle unreacted A, with a purge to remove by-product B.



Or you may decide to use a second separator.



Design Competition

There are two types of reactors:

Type 1: High conversion, modest selectivity of *P* over *B*.
Type 2: Low conversion, good selectivity of *P* over *B*.

There are two types of the first separator:

Type 1: High recovery of *P*; low *P*:*A* ratio in liquid the liquid stream.
Type 2: Low recovery of *P*; moderate *P*:*A* ratio in liquid the liquid stream.

There are two types of the (optional) second separator:

Type 1: Excellent separation; high *A*:*B* ratio in the tops, low *A*:*B* ratio in the bottoms)
Type 2: Modest separation; good *A*:*B* ratio in the tops, moderate *A*:*B* ratio in the bottoms

The types of reactor, first separator, and second separator are dictated by the last digit of your CU NetID.

In general, equipment with better specifications has a higher price and costs more to operate. There is economy of scale; the equipment price is proportional to $(\text{capacity})^{0.6}$

You must decide process units capacities and production rates. Economic data are provided in a separate file.

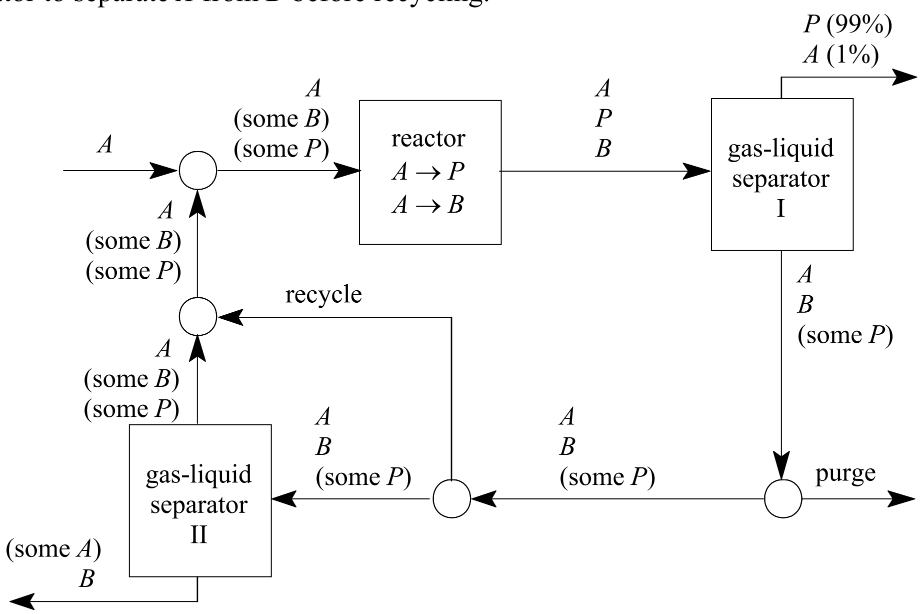
Your fiducial goal is to achieve an ROI greater than zero. Additional rewards are earned for an ROI greater than 0.20 and the highest ROI in your Division.

EngrD 2190 - Mass & Energy Balances
Design Competition - Fall 2017 - Part 1.

Your company has decided to produce *P* by the reaction $A \rightarrow P$. Unfortunately, there is a parallel reaction, $A \rightarrow B$. Both reactions are irreversible. Both reactions are incomplete; the reactor effluent contains reactant *A*, product *P* and worthless by-product *B*.

The boiling points at 1 atm are *P* (30°C), *A* (50°C), and *B* (55°C). Purifying *P* to ≥99% (minimum purity to sell) by distillation is easy, but separating *A* and *B* is more difficult.

A generic process is shown below. To produce and sell product *P*, you need only a reactor and separator I. You have three options for the *A*+*B* mixture in the "separator I bottoms" stream: (1) you may discard the *A*+*B* mixture by sending 100% of the stream to the purge, or (2) you may recycle some of the *A*+*B* mixture, for example, by purging 50% and sending 50% through the recycle, or (3) you may purchase a second separator to separate *A* from *B* before recycling.



There are two options for the reactor. Reactor Type 1 has a high conversion of *A* but has poor selectivity for *P* over *B*. Another reactor has a lower conversion of *A*, but has better selectivity for *P* over *B*.

There are two options for separator I. Both options produce a tops product with 99% *P*, but differ by the amount of *P* in the liquid bottoms. Separator I Type 1 recovers more of the product *P* (the ratio *P*:*A* in the bottoms is <1:20). Separator I Type 2 allows more *P* to escape via the liquid stream, but is smaller and less expensive to operate.

If one decides to purchase a second separator, there are two options for separator II. The expensive option (Type 1) has a high *A*:*B* ratio in the tops and a low *A*:*B* ratio in the bottoms. The cheaper option (Type 2) has a moderate *A*:*B* ratio in the tops and a moderate *A*:*B* ratio in the bottoms.

Because *B* is toxic, disposal requires special treatment and is expensive. The disposal cost is determined by the total amount of any effluent that contains *B*. That is, the disposal cost for 1 mol of a mixture with 10% *A* and 90% *B* is the same as the disposal cost for 1 mol with 90% *A* and10% *B*.

Engineering and Economic Data for Manufacturing *P* from *A*.

Equipment specifications, equipment costs, operating costs, chemical costs, and disposal costs vary with Design League and Division. Identify your team's League and Division and then download the data from the EngrD 2190 homepage - see "Design Competition."

Wednesday Design League:	Galbraith Division: Teams W1 - W5
	Keynes Division: Teams W6 - W10
	Smith Division: Teams W11 - W16
Thursday Design Leagues:	Friedman Division: Teams Th1-Th6
	Von Mises Division: Teams Th7-Th12

Reactor and separator prices are given by the formula $price = k \times (F_T)^{0.6}$, where k is a constant conversion factor, F_T is the flow through the unit, in mol/day, and *price* is in \$. For example, a reactor with double the capacity costs only 1.5 times as much. Operating costs for reactors and separators are given by the formula $operating\ cost = c \times F_T$; the units of *operating cost* are \$/year.

All economic parameters - equipment prices, operating costs, chemical prices, and disposal cost - are constant. Equipment depreciation is calculated with straight-line formula, with a lifetime of 10 years. The process operates 365 days/year.

Equipment purchase costs are paid at the beginning of the year. Operating costs are paid during the year. Revenue from *P* sales is received at the end of the year.

Goal: Start with $10,000,000 and maximize the ROI for your process in the first year.

You must decide what type of reactor, separator I, and separator II (if any) to purchase, and the capacity of each. You must specify the fraction of Separator I bottoms to be purged and the fraction to be recycled. You also must decide how much reactant to purchase.

Annual Plans are due by 2:30 p.m. on the day of your Calculation Session, either Wednesday October 18 or Thursday October 19. You will receive an Annual Report of your team's results by Friday, October 20.

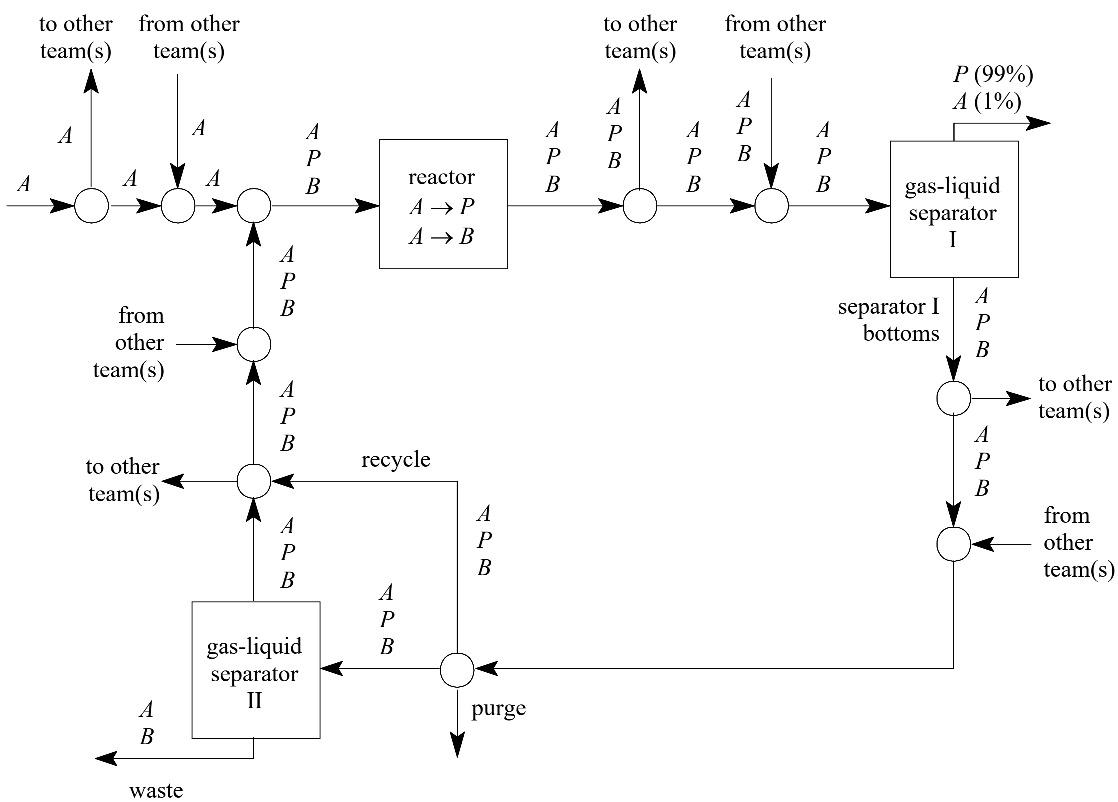
If your team achieves a positive Return On Investment, your team will receive 25 homework points. If your ROI is greater than 0.2, your team will receive an additional 10 points. If your team has the highest Return On Investment in your Division, your team will receive an additional 10 points.

EngrD 2190 - Mass & Energy Balances
Design Competition - Fall 2017 - Part 2.

In addition to buying reactant *A* and selling product *P*, you may buy and sell intermediate compositions by trading with other companies. For example, you may decide to buy only a reactor – no separators. Because the reactor price scales non-linearly, your reactor should be able to produce reactor effluent cheaper than smaller reactors. You should be able to supply other companies with reactor effluent at a price below their cost to manufacture it. Both companies benefit.

Or perhaps your company may decide to invest in a large separator II. Perhaps your company can charge less than the disposal cost for *A*+*B* mixtures. So other companies will give you *A*+*B* mixtures *and* pay you a fee less than the disposal cost. You can sell reactant (nearly pure) *A* for less than the market rate. All companies may benefit.

Thus the process flowsheet is modified as follows:



What price to charge for reactor effluent? What price to pay for reactor effluent? What fee to charge for disposing *A*+*B* mixtures? Prices and fees must be negotiated between companies.

Trading with other companies is optional; you may eschew intercompany entanglements and operate independently.

Rules:

This is a new competition. Every team is starting with $10,000,000 and no equipment. The costs and equipment specifications are unchanged from the previous competition.

Annual Plans and Contracts (optional) are due by 3:00 p.m. on the day of your Calculation Session, either Wednesday October 25 or Thursday October 26. You will receive an Annual Report of your team's results by Friday, October 27.

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More Rules.

Teams may write contracts with other teams in their League and Division only.

Because a company will depend on another company fulfilling the contract, the contracts have a provision for penalties. For example, if a company agrees to supply Reactor Type-1 effluent at 50.0 mol/day, but fails to do so, that company must pay the penalty stated on the contract.

Services and cash from contracts (see below) exchange during the year.

Company X may not give its money to company Y, even if company X has a contract to be repaid by company Y, with interest or a share of the profits. This contract is essentially a merger of two companies into a single company with twice the assets. The competition is intended to exercise engineering design and negotiation skills, so all companies should start with the same resources.

Every contract must be a reasonable exchange of process streams and/or cash. Every contract must be explicit. Cash amounts must be specific numbers. For example, contracts with payments described as "half the profits" will not be accepted.

Equipment may not be exchanged between companies. If your company needs additional processing capacity and another company has excess processing capacity, your companies should arrange to exchange process streams, such as reactor effluent, or separator I bottoms, for example.

The forms for Annual Plans and InterCompany contracts are posted at the EngrD 2190 homepage. You are welcome to download the MS Word files and modify the forms, for example, to allow for the purchase of two reactors. Or you may wish to type your comments onto the form.

In summary, Annual Plans and InterCompany Contracts must be unambiguous. Add comments to indicate precisely how each equipment purchase is to be used. If you have questions, please ask. I will try to respond promptly to e-mail by the next business day and I am available during office hours, 2-4 p.m. Wednesdays.

Goal: Start with $10,000,000 and maximize the ROI.

If your team achieves a positive Return On Investment, your team will receive 25 homework points. If your ROI is greater than 0.2, your team will receive an additional 10 points. If your team has the highest Return On Investment in your Division, your team will receive an additional 10 points.