The Beef Industry

The United States beef industry produced 27 billion pounds of beef last year. That's a lot of beef! To keep production high, there are several different segments within the beef industry. These segments all play a part in the production of beef. Without one of these segments, the industry would not be able to produce as much beef or as high quality of beef.

Cow-Calf Operation

Calves are produced at a cow-calf operation. This is usually a farm with large herds of cows. The rancher buys bulls to breed his cows, then sells the offspring once they reach 600-700 pounds. Typically, calves are kept at the farm for 9 months before they are sold. This gives the calves time to wean off of their mother's milk and get used to eating a grass diet before they are taken to the sale.

Feedlot or Stocker Facility

At the sale, the calves can be purchased by a stocker facility or a feedlot.

- Stocker facility: Stockers serve as a middle-man between the cow-calf operation and the feedlot. Here, calves are kept on pastures to gain a bit more weight before they go to the feedlot. This usually happens to calves that aren't heavy enough to meet feedlot requirements.
- Feedlot: At the feedlot, animals are fed a special ration formulated by a livestock nutritionist. This ration helps them gain weight.

Packing Plant

After animals are fed at a feedlot, they are transported to a packing plant. A packing plant is a facility where animals are harvested using humane techniques. The animal's carcass is then disassembled into products that we consume (like steaks, hamburger, and ribs).

Grocery Stores, Restaurants, and Other Stores

The products from the packing plant are transported to stores to be sold to customers.

Formulating Rations

STEM CAREER ADVENTURES

Let's take a closer look at one segment of the beef industry: Feedlots.

Because feedlots have thousands of head of cattle, they must follow a very strict schedule to make sure that they are maximizing their profits. Feedlots have a "day limit" for cattle. This day limit ensures that cattle are entering and leaving the feedlot within a certain time frame. For example: cattle that come into the feedlot weighing 600 pounds have 200 days to leave the feedlot weighing 1200 pounds. To meet this goal, the animal must gain an average of 3 pounds per day.

When feeding animals in a feedlot, it is important that animals are feed efficient. This means that the animals should be fed a diet that allows them to gain weight quickly. In a feedlot situation, we would not provide an animal with only grass hay and expect them to gain 2 pounds a day—grass hay does not have a high enough energy or protein content to enable animals to gain that much weight that quickly. Instead, we use equations to mix ingredients into a balanced ration that will help us accomplish our goals for the cattle that we are feeding.

Here is an example of why feed efficiency is important:

- Imagine two steer calves placed on feed. Both steers are gaining an average of 3.5 pounds per day.
  - Over time, we measure that Steer A consumes an average of 21 lbs per day, which equates to a 6:1 feed to gain ratio.
    - To determine this ratio, we take (21 lbs feed/day) divided by (3.5 lbs gained/day) and determine that the calf is eating 6 pounds of feed for every pound of gained weight.
  - Steer B consumes 28 lb/day, which equates to a F:G of 8:1, and therefore is less feed efficient than Steer A.
    - To determine this ratio, we take (28 lbs feed/day) divided by (3.5 lbs gained/day) and determine that the calf is eating 8 pounds of feed for every pound of gained weight.
  - This calf is less feed efficient than Steer A, because this calf needs to eat 8 pounds of feed, which is more than the 6 pounds required by Steer A.

- Based on a ration cost of $173/ton (or 0.0865 cents per pound):
  - Steer A costs $1.82 to feed per day.
    - (0.0865 cents/lb * 21 lbs/day = $1.8165)
    - The animal will be at the feedlot for 200 days. Steer A costs a total $364 to feed for 200 days.
  - Steer B costs $2.42 to feed per day.
    - (0.0865 cents/lb * 28 lbs/day = $2.42)
    - The animal will be at the feedlot for 200 days. Steer B costs $484 to feed for 200 days.
  - If both steers reach their finish weight in 200 days, the less feed efficient animal (Steer B) would cost the producer $120 more to finish than an animal with better feed efficiency (Steer A).

It is obvious based on these calculations that it would be advantageous for feedlots to make sure that they only have feed efficient cattle. This can be tricky—some cattle are more feed efficient than others, based on their genetic makeup. However, feedlot owners can also help cattle be feed efficient when they are deciding what the animal should eat during their time at the feedlot.

Feedlot owners work with livestock nutritionists to determine what nutrients their animals need to stay healthy, meet their daily maintenance requirements (the calories needed to just maintain weight) and the requirements needed to gain weight—all things that help an animal be more feed efficient. This helps the feedlot make better decisions about the diet that their animals will consume, and about how much money they will spend on an animal's feed.

Rations

Livestock nutritionists are responsible for creating rations for animals. A ration is a carefully selected mixture of ingredients that is designed to meet an animal's nutritional requirements and help an animal achieve whatever goal the producer has in mind. For example, if a producer wants her cattle to gain 3 pounds a day, the ration will include ingredients with enough energy, protein, and minerals for the cattle to gain 3 pounds a day. If a different producer wants to provide a maintenance feed for wintertime that will allow his cattle to maintain their current weight, the ration will include ingredients with the right balance of energy, protein, and minerals to ensure that the cattle maintain their current weight.

When feedlot owners consult livestock nutritionists to create a ration for their feedlot, they are typically focused on a ration that will help their cattle gain weight quickly. This is because the feedlot owners are on a schedule—cattle come in weighing a certain amount, stay for about 200 days, and must leave weighing a certain amount. Rations for feedlots are usually full of energy and protein. All of this energy and protein helps the cattle gain weight quickly.

Energy in livestock rations is measured in Total Digestible Nutrients (TDN). The TDN of a ration is a measure of the nutrients in the feed that can be digested by the animal. There are some nutrients in the feed that can't be digested by the animal; these simply pass through the animal in their feces or urine. The TDN is found using a formula that factors in the following measurements:

- **Nitrogen-Free Extract (NFE):** This is a measure of the carbohydrates in a feed. Sugars and starches are examples of carbohydrates. NFE is calculated as the percentage of feed that is not moisture, protein, fiber, fat, or ash (vitamins and minerals).
- **Crude fiber (CF):** Fiber is the tough part of the plant, the part that gives it structure.
- **Crude protein (CP):** Protein is necessary for proper growth of the animal's structure and muscle.
- **Ether extract (EE):** Also known as crude fat. Fat is an extremely high source of energy, so it is given greater weight than the other nutrients when calculating TDN.

The formula is: **TDN = digestible NFE + digestible CF + digestible CP + (digestible EE x 2.25)**

The measurements that are used in this formula are found by performing a feed-drying process. This process removes all of the moisture from the feed. Then, it is placed through a series of tests that determine the different nutrient levels in the feed. Once these tests are complete, the livestock nutritionist is left with the nutrient content on a "dry-matter" basis. A dry-matter basis means that the nutrients in the feed are measured while the feed is completely dry, with all moisture removed. This is important because the moisture (water) in the feed can dilute the nutrient content in the feed, which can result in lower nutrient concentrations. Lower concentrations can make a feed look less "potent" or packed with nutrients than it really is. When ingredient analysis is performed on feed with moisture intact, the nutrient content is reported on an "as-fed" basis. This means that the feed is "as-fed", or as you would feed it to the animal. This feed does not go through the special drying process to remove moisture.

Formulating Rations

Because the TDN calculation accounts for fiber, fat, protein, and carbohydrates, livestock nutritionists usually begin the process of choosing ingredients for a ration based on an animal's TDN. After they balance for TDN, they balance for the crude protein (CP) in the ration. Both TDN and crude protein are very important to the health and weight gain of an animal. These requirements can vary based on the following factors:

- Gender of the animal: Male cattle, called bulls or steers (when they are castrated) typically require more feed than female cattle, called cows or heifers.
- Reproductive status of the animal: Pregnant or lactating cattle require more nutrients than cows that aren't.
- Goal of livestock producer: The TDN and CP requirements can change according to the goal of the livestock producer. Producers like feedlots feed their animals a ration with a higher TDN and CP than other producers, because they want their animals to gain weight as quickly as possible.

Once a livestock nutritionist understands the animal's TDN requirements, they begin a process that is called "balancing" a ration. Balancing means that the livestock nutritionist determines exactly how much of each ingredient must be included in a ration to meet an animal's TDN or crude protein requirements.

These are the steps that livestock nutritionists follow in order to balance a ration:

- Perform feed analysis tests to determine the nutrient levels present in different ration ingredients.
    - Samples from unique locations can differ in their nutrient composition, so it is important to test the feed that will actually be used for the ration. If feed analysis cannot be performed, livestock nutritionists use tables that have average data for each ingredient. These data are averages over thousands of feed analyses.
- Determine the animal's requirements.
    - Remember, an animal's TDN and CP requirements can vary. It is important that the livestock nutritionist determine the age and sex of the animals that the ration will be fed to, along with reproductive status and the goal of the producer, prior to balancing a ration.
- Decide which ingredients to use in the ration.
    - The livestock producer chooses ration ingredients based on nutrient composition, price, and availability near the producer. For a feedlot, corn is readily available and can be shipped from nearby places, is typically reasonably priced, and is very nutrient dense.
- Balance the ration.
    - Livestock nutritionists use math to balance equations to ensure that the ration includes the proper TDN and CP for the producer's goal for the animal to be accomplished. During this process, the livestock nutritionist finds out exactly how much of each ingredient will need to be used to meet the animal's requirements. Nutritionists can balance for any ingredient (fat, protein, minerals, vitamins, protein, TDN, etc.), but TDN and CP are the main two.

- For high energy rations (such as rations containing large amounts of corn), develop a starter rationA starter ration is a ration that is still balanced for the animal's requirements, but contains less corn than the high energy ration. This helps the animal's digestive system get used to eating large amounts of corn. If a starter ration isn't used, the animal can develop liver abscesses, which can cause digestive issues that prevent the animal from gaining the desired weight at a feedlot.

Balancing a Ration

It's time to balance a ration for the feedlot you've been hired by. This feedlot purchases calves that weigh approximately 600 lbs, and finish at 1200 lbs. The nutrient requirements for the animals are listed in the table below.

Table 1: Nutrient Requirements

Calf Weight	Ration Type	Dry Matter Intake (lbs)	% Total Digestible Nutrients (TDN)	% Crude Protein
600 lbs	Starter	13.7	67.5 %	11.4 %
650 lbs	Grower	15.1	73.4 %	12.1 %
1150 lbs	Finisher	25.4	61.3 %	7.3 %

Table 2: Nutrient Composition of Ration Ingredients

Ingredient	% Dry Matter	% TDN	% Crude Protein
Steam flaked corn	85	93	9.2
Barley hay	90	57	9
Soybean meal	89	84	49.9

Formulating Rations

Balance Starter Ration:

The first step to balance the ration is to calculate the TDN. Remember, the Total Digestible Nutrients value in the table describes the percentage of the nutrients in the feed that can be digested and utilized by the animal.

Step 1: Find the values you need to calculate TDN for the starter ration.

Use the values for % TDN for steam flaked corn and barley hay found in Table 2. The animal's TDN requirement is found in Table 1.

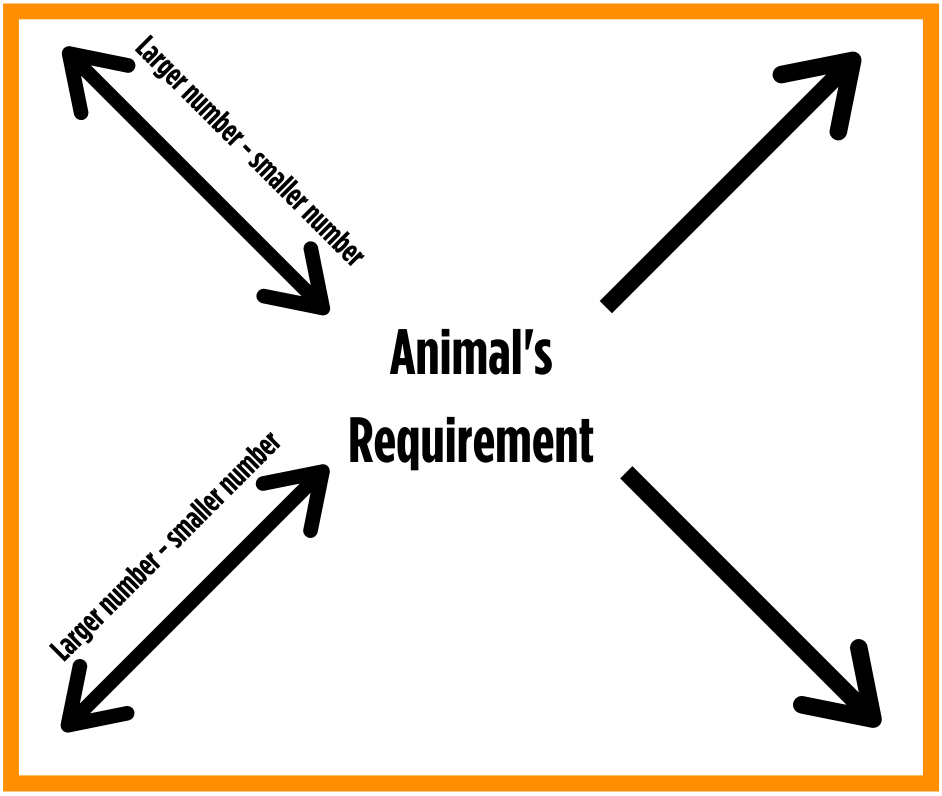
%TDN steam flaked corn: 93 %TDN barley hay: 57 %TDN requirement for 600 lbs calf: 67.5

Step 2: Use Pearson Square

Now that you have the values that you need, you will plug them into a Pearson Square. A Pearson Square is a tool that allows a livestock nutritionalist to calculate the ratio of the different parts of the ration.

The Pearson Square below shows what values go in each space.

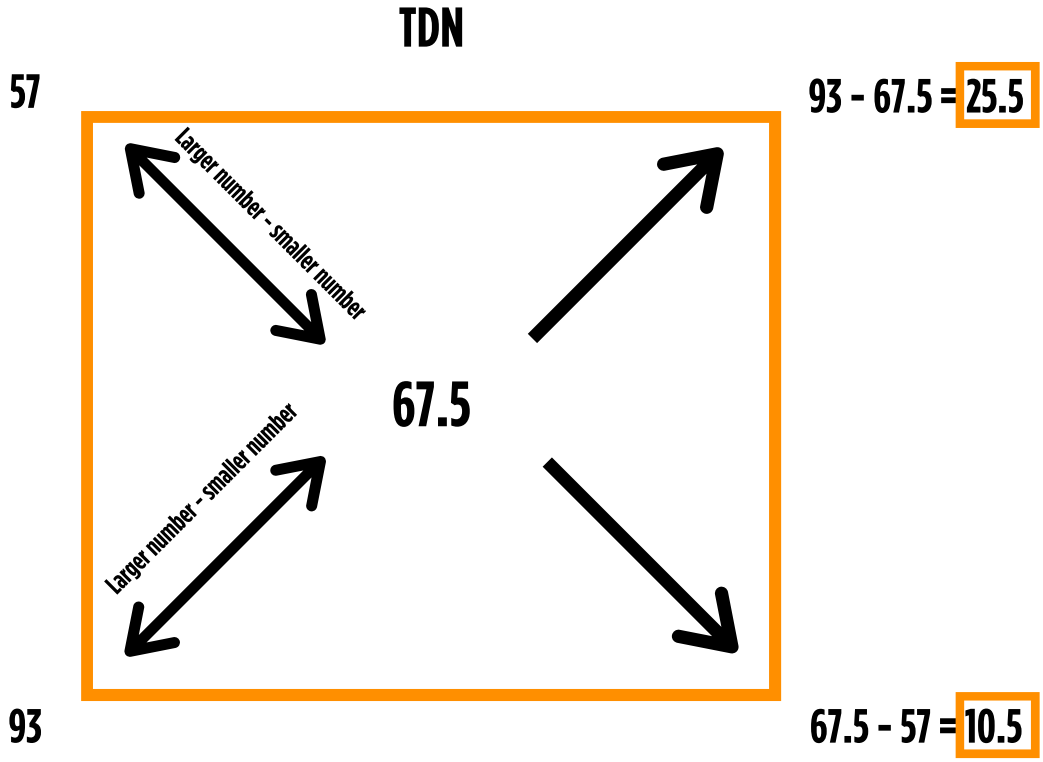
Barley Hay **Parts Barley Hay**



Steam flaked Corn **Parts Steam flaked Corn**

Formulating Rations

Now we will plug in our numbers to the Pearson Square:



Next, add the parts barley hay to the parts steam flaked corn to get the total parts for the ration:

- 25.5 parts barley hay + 10.5 parts steam flaked corn = 36 total parts

Step 3: Calculate the percentages of each ingredient in the ration.
To do this, we will take the number of parts required (from our Pearson Square calculations) divided by the total number of parts needed for the ration.

$$\frac{\text{25.5 parts barley hay}}{\text{36 total parts}} = \text{71\% barley hay in ration}$$

$$\frac{\text{10.5 parts steam flaked corn}}{\text{36 total parts}} = \text{29\% steam flaked corn in ration}$$

This ration will be mixed at 29% steam flaked corn, and 71% barley to balance for TDN.

Formulating Rations

Step 4: Balance Protein in Ration

First, we have to determine the protein that is found in the ration that we just balanced.

- To do this, we will multiply the percentage of the ingredient in the total ration by the crude protein in each ingredient.
- You will find the crude protein values for each ingredient in Table 2.

(0.71 barley in total ration) x (9.0% crude protein) = 6.39%

This means that the barley hay is contributing 6.39% of the protein found in the ration.

(0.29 steam flaked corn in total ration) x (9.2% crude protein) = 2.67%

This means that the steam flaked corn is contributing 2.67% of the protein found in the ration.

Add the two ingredients together: (6.39 + 2.67) = 9.06% protein in ration

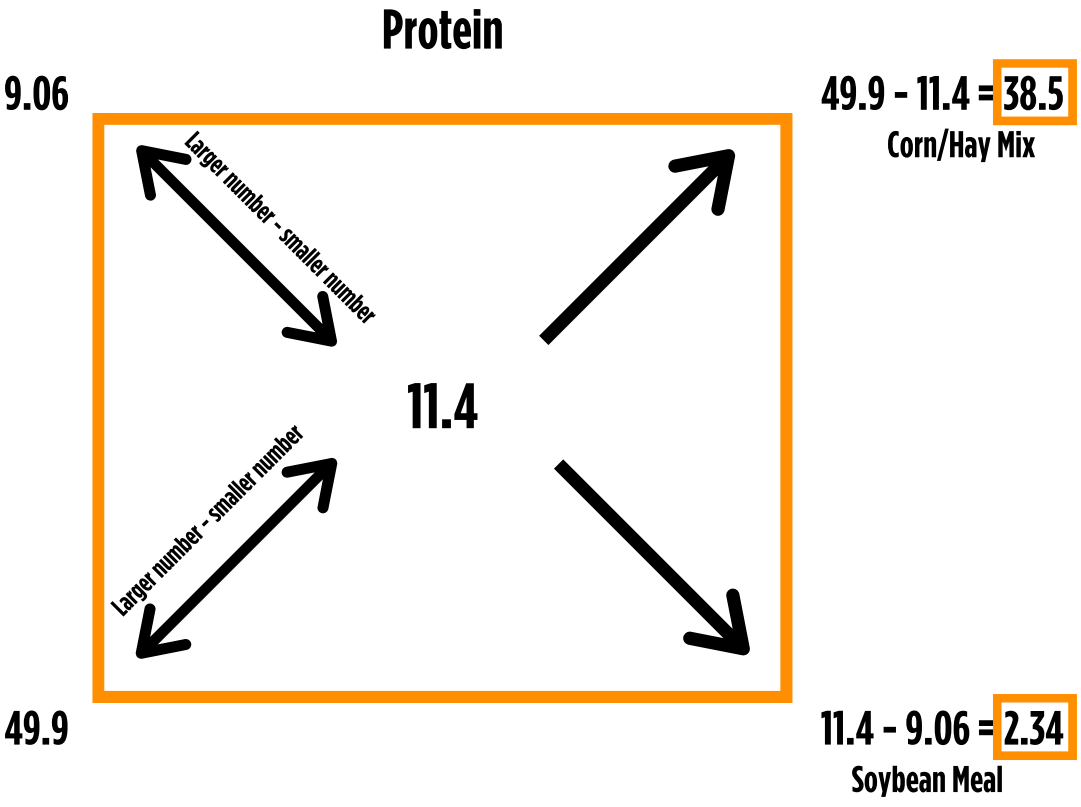
Next, look up the crude protein requirement for the starter ration in Table 1.

- The crude protein requirement is 11.4%.
- The ration does not meet the requirement for crude protein. To fix this, we will have to add a protein supplement.

Step 5: Balance for Protein Supplement

Now we will balance for the protein supplement (soybean meal) that will be necessary to add to the ration to meet the protein requirement.

- We are going to use the Pearson Square method again.
  - In the top left corner, use the total protein from the ration that you calculated in the last step. For this ration, our total protein was 9.06%.
  - In the bottom left corner, use the crude protein found in soybean meal. This value is found in Table 2.



- Now that we have the parts for the ration, we will add them together to determine the total parts:
  - 38.5 parts steam flaked corn and barley hay mixture + 2.34 parts soybean meal = 40.84 total parts

- Next, divide the individual parts by the total parts:
  - 38.5 parts steam flaked corn and barley hay mixture / 40.84 total parts = 94.28% steam flaked corn and barley hay mixture
  - 2.34 parts soybean meal / 40.84 total parts = 5.72% soybean meal

At this point, we know that the TDN and Protein in the ration are balanced. This means that the ration (steam flaked corn, barley hay, and soybean meal mixture) is providing the right amount of energy and protein to the calves.

Step 6: Determine the Pounds of Dry Matter Required

In this step, we will determine the number of pounds that we would need to feed the cattle on a dry matter basis. Remember, a "dry matter basis" means that we are working strictly with dried feeds, or feeds that have had all water removed.

- To find the pounds of dry matter required, use the Dry Matter Intake requirements found in Table 1 for the starter ration.
  - The DMI requirement for the starter ration is 13.7 lbs.

- Next, multiply the DMI requirement by the ingredient percentage (calculated in the last step).
  - (13.7 lbs) x (5.72% soybean meal) ---> (13.7 x 0.0572) = 0.78 lbs soybean meal
  - This means that the animal must consume 0.78 pounds of soybean meal per day.

- (13.7 lbs total dry matter intake required) - (0.78 lbs soybean meal required) = 12.92 lbs remaining
  - 12.92 pounds are remaining in the dry matter intake requirement. This requirement must be met with the steam flaked corn/barley hay mixture.

- To determine how much of each ingredient to use, multiply the remaining DMI (12.92) by the ingredient percentage (calculated in Step 3).
  - 12.92 lb DMI required x (71% barley) = (12.92 x 0.71) = 9.17 lbs barley

- Now that we know the amount of barley we need to feed, we will calculate the amount of corn we need:
  - 12.92 lbs DMI required - 9.17 lbs barley = 3.75 lbs steam flaked corn

Step 7: Determine the Pounds As-Fed

In this step, we will determine the pounds "as-fed" for the ration. "As-fed" means the total weight of the ingredient in the real world, meaning that "as-fed" ingredients have not had water removed.

- To convert to as fed, divide the pounds of dry matter (calculated in the last step) by the percent dry matter (found in Table 2).

- Barley: (9.17 lbs DM) / (90% DM) = (9.17 / 0.90) = 10.19 lbs barley
- Steam flaked corn: (3.75 lbs DM) / (85% DM) = (3.75 / 0.85) = 4.4 lbs steam flaked corn
- Soybean meal: (0.78 lbs DM) / (89% DM) = (0.78 / 0.89) = 0.88 lbs soybean meal

These numbers represent the weight of each ingredient in the ration for one calf at the feedlot.

Step 8: Determine the Amounts of Each Ingredient for Batch Mixing

At the feedlot, rations are not prepared on a per-animal basis. Instead, they are created for entire pens of animals. Imagine that the feedlot just bought a pen of 300 cattle. They want to feed your starter ration, and they want to know how much of each ingredient they need to add to mix enough ration for 300 cattle.

- To determine how much of each ingredient is required for 300 cattle, multiply the as-fed pounds (determined in the last step) for each ingredient by 300.

    - (10.19 lbs barley) x 300 = 3,057 lbs barley
    - (4.4 lbs steam flaked corn) x 300 = 1,320 lbs steam flaked corn
    - (0.88 lbs soybean meal) x 300 = 264 lbs soybean meal

FINALLY! The Livestock Nutritionalist knows that in order to feed 300 cattle a starter ration, they need to mix: 3,057 lbs of barley, 1,320 lbs of steam flaked corn, and 264 lbs of soybean meal

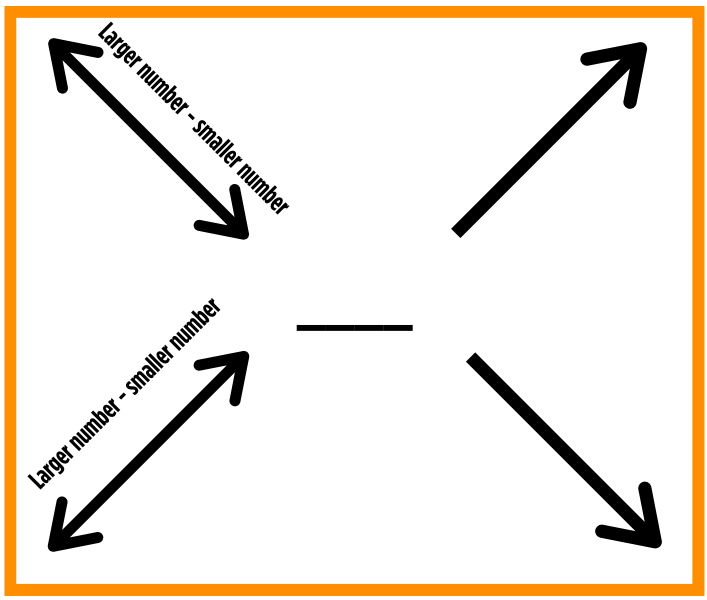
Balance Grower Ration

Balance the grower ration for the feedlot.

Step 1: Find the values you need to calculate TDN for the GROWER ration.
Use the values for % TDN for steam flaked corn and barley hay found in Table 2. The animal's TDN requirement is found in Table 1.

%TDN steam flaked corn: _____ %TDN barley hay: _____ %TDN requirement for 600 lbs calf: _____

Step 2: Use Pearson Square
Insert the values for steam flaked corn and barley hay into the Pearson Square:



Next, add the parts barley hay to the parts steam flaked corn to get the total parts for the ration:

_____ parts barley hay + _____ parts steam flaked corn = _____ total parts

Step 3: Calculate the percentages of each ingredient in the ration.
To do this, we will take the number of parts required (from our Pearson Square calculations) divided by the total number of parts needed for the ration.

$$\frac{\text{\_\_\_\_\_ parts barley hay}}{\text{\_\_\_\_\_ total parts}} = \text{\_\_\_\_\_\% barley hay in ration}$$

$$\frac{\text{\_\_\_\_\_ parts steam flaked corn}}{\text{\_\_\_\_\_ total parts}} = \text{\_\_\_\_\_\% steam flaked corn in ration}$$

Step 4: Balance Protein in Ration
First, we have to determine the protein that is found in the ration that we just balanced.

- To do this, we will multiply the percentage of the ingredient in the total ration by the crude protein in each ingredient.
- You will find the crude protein values for each ingredient in Table 2.

(_____ barley in total ration) x (9.0% crude protein) = _____

(_____ steam flaked corn in total ration) x (9.2% crude protein) = _____

Add the two ingredients together:

_____ protein from barley + _____ protein from corn = _____ protein in ration

Next, look up the crude protein requirement for the starter ration in Table 1.

- The crude protein requirement is _____%

- Does the ration meet the requirement for crude protein? (Circle your answer)

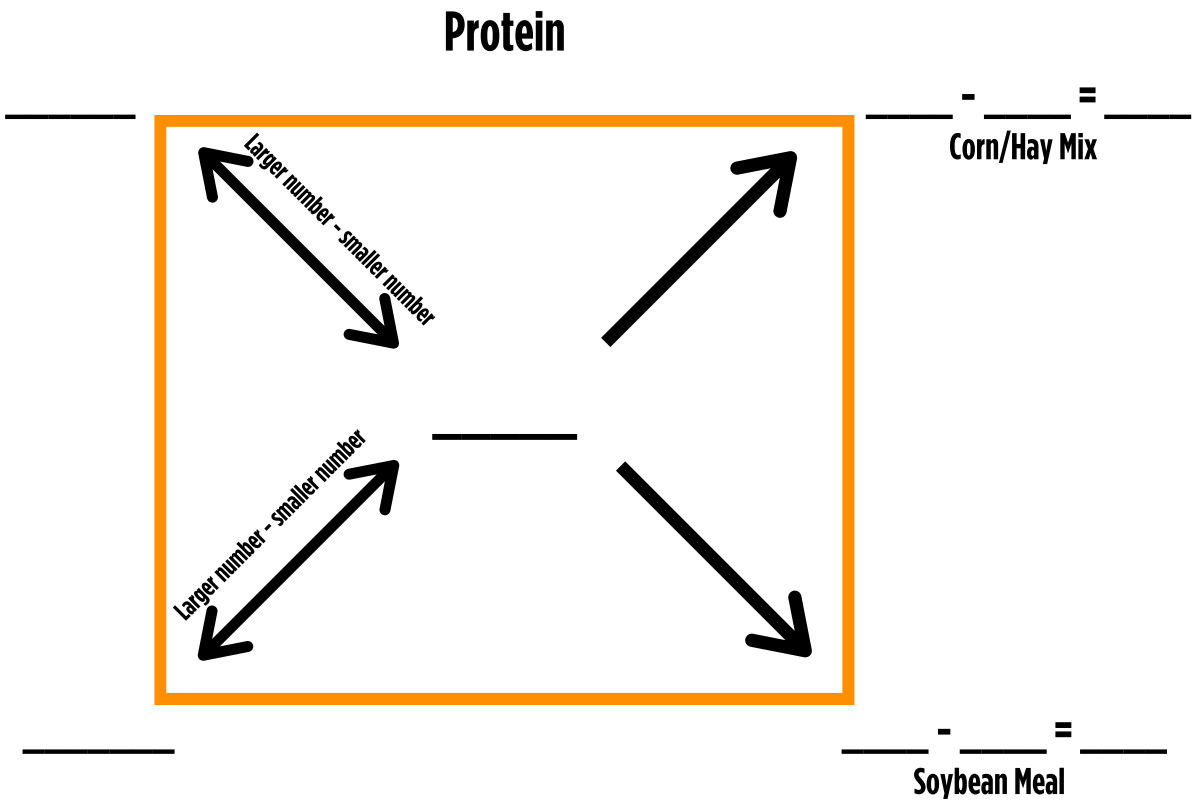
Yes No

Formulating Rations

Step 5: Balance for Protein Supplement

Now we will balance for the protein supplement (soybean meal) that will be necessary to add to the ration to meet the protein requirement.

- We are going to use the Pearson Square method again.
  - In the top left corner, use the total protein from the ration that you calculated in the last step.
  - In the bottom left corner, use the crude protein found in soybean meal. This value is found in Table 2.



- Now that we have the parts for the ration, we will add them together to determine the total parts:
  - _____ parts steam flaked corn and barley hay mixture + _____ parts soybean meal = _____ total parts
- Next, divide the individual parts by the total parts:
  - _____ parts steam flaked corn and barley hay mixture / _____ total parts = _____% steam flaked corn and barley hay mixture
  - _____ parts soybean meal / _____ total parts = _____% soybean meal

Formulating Rations

Step 6: Determine the Pounds of Dry Matter Required

In this step, we will determine the number of pounds that we would need to feed the cattle on a dry matter basis. Remember, a "dry matter basis" means that we are working strictly with dried feeds, or feeds that have had all water removed.

- To find the pounds of dry matter required, use the Dry Matter Intake requirements found in Table 1 for the grower ration.
    - The DMI requirement for the grower ration is _____ lbs.

- Next, multiply the DMI requirement by the ingredient percentage (calculated in the last step).
    - _____ lbs DMI x _____ soybean meal (remember to turn your soybean meal percent into a decimal) = _____
    - This means that the animal must consume this many pounds of soybean meal per day.

- _____ lbs total DMI required - _____ lbs soybean meal required = _____ lbs remaining
- This requirement must be met with the steam flaked corn/barley hay mixture.

- To determine how much barley to use, multiply the remaining DMI by the ingredient percentage (calculated in Step 3).
    - _____ lb DMI required x _____ barley (remember to turn your barley percent into a decimal) = _____ lbs barley

- Now that we know the amount of barley we need to feed, we will calculate the amount of corn we need:
    - _____ lbs DMI required - _____ lbs barley = _____ lbs steam flaked corn

Step 7: Determine the Pounds As-Fed

In this step, we will determine the pounds "as-fed" for the ration. "As-fed" means the total weight of the ingredient in the real world, meaning that "as-fed" ingredients have not had water removed.

- To convert to as fed, divide the pounds of dry matter (calculated in the last step) by the percent dry matter (found in Table 2).
  - Don't forget to change your percents into decimals before calculating!

- Barley: _____ lbs DM / _____ % DM = _____ lbs barley
- Steam flaked corn: _____ lbs DM / _____ % DM = _____ lbs steam flaked corn
- Soybean meal: _____ lbs DM / _____% DM = _____ lbs soybean meal

These numbers represent the weight of each ingredient in the ration for one calf at the feedlot.

Step 8: Determine the Amounts of Each Ingredient for Batch Mixing

At the feedlot, rations are not prepared on a per-animal basis. Instead, they are created for entire pens of animals. Imagine that the feedlot just bought a pen of 300 cattle. They want to feed your grower ration, and they want to know how much of each ingredient they need to add to mix enough ration for 300 cattle.

- To determine how much of each ingredient is required for 300 cattle, multiply the as-fed pounds (determined in the last step) for each ingredient by 300.
  - _ _____ lbs barley x 300 = _____ lbs barley
  - _____ lbs steam flaked corn x 300 = _____ lbs steam flaked corn
  - _____ lbs soybean meal x 300 = _____ lbs soybean meal

FINALLY! The Livestock Nutritionalist knows that in order to feed 300 cattle a grower ration, they need to mix:

_____ lbs of barley,

_____ lbs of steam flaked corn, and

_____ lbs of soybean meal

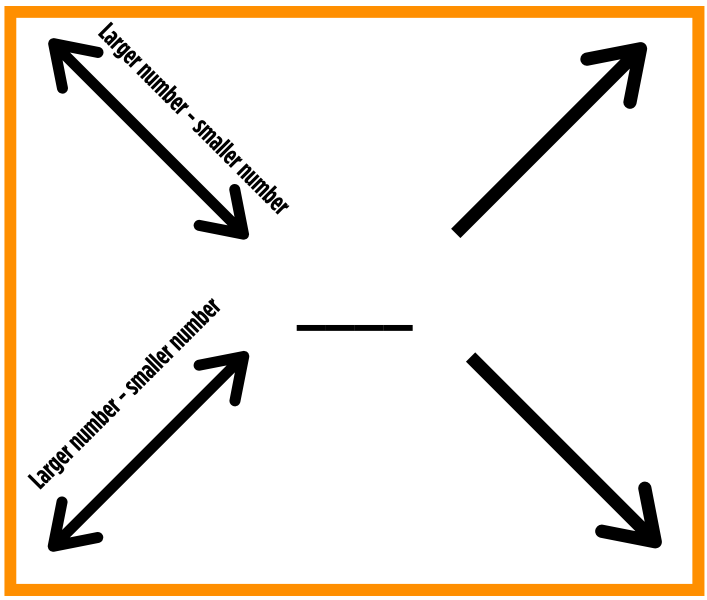
Balance Finisher Ration

Balance the finisher ration for the feedlot.

Step 1: Find the values you need to calculate TDN for the FINISHER ration.
Use the values for % TDN for steam flaked corn and barley hay found in Table 2. The animal's TDN requirement is found in Table 1.

%TDN steam flaked corn: _____ %TDN barley hay: _____ %TDN requirement for 600 lbs calf: _____

Step 2: Use Pearson Square
Insert the values for steam flaked corn and barley hay into the Pearson Square:



Next, add the parts barley hay to the parts steam flaked corn to get the total parts for the ration:

_____ parts barley hay + _____ parts steam flaked corn = _____ total parts

Formulating Rations

Step 3: Calculate the percentages of each ingredient in the ration.
To do this, we will take the number of parts required (from our Pearson Square calculations) divided by the total number of parts needed for the ration.

$$\frac{\text{\_\_\_\_\_ parts barley hay}}{\text{\_\_\_\_\_ total parts}} = \text{\_\_\_\_\_\% barley hay in ration}$$

$$\frac{\text{\_\_\_\_\_ parts steam flaked corn}}{\text{\_\_\_\_\_ total parts}} = \text{\_\_\_\_\_\% steam flaked corn in ration}$$

Step 4: Balance Protein in Ration
First, we have to determine the protein that is found in the ration that we just balanced.

- To do this, we will multiply the percentage of the ingredient in the total ration by the crude protein in each ingredient.
- You will find the crude protein values for each ingredient in Table 2.

(_____ barley in total ration) x (9.0% crude protein) = _____

(_____ steam flaked corn in total ration) x (9.2% crude protein) = _____

Add the two ingredients together:

_____ protein from barley + _____ protein from corn = _____ protein in ration

Next, look up the crude protein requirement for the starter ration in Table 1.

- The crude protein requirement is _____%

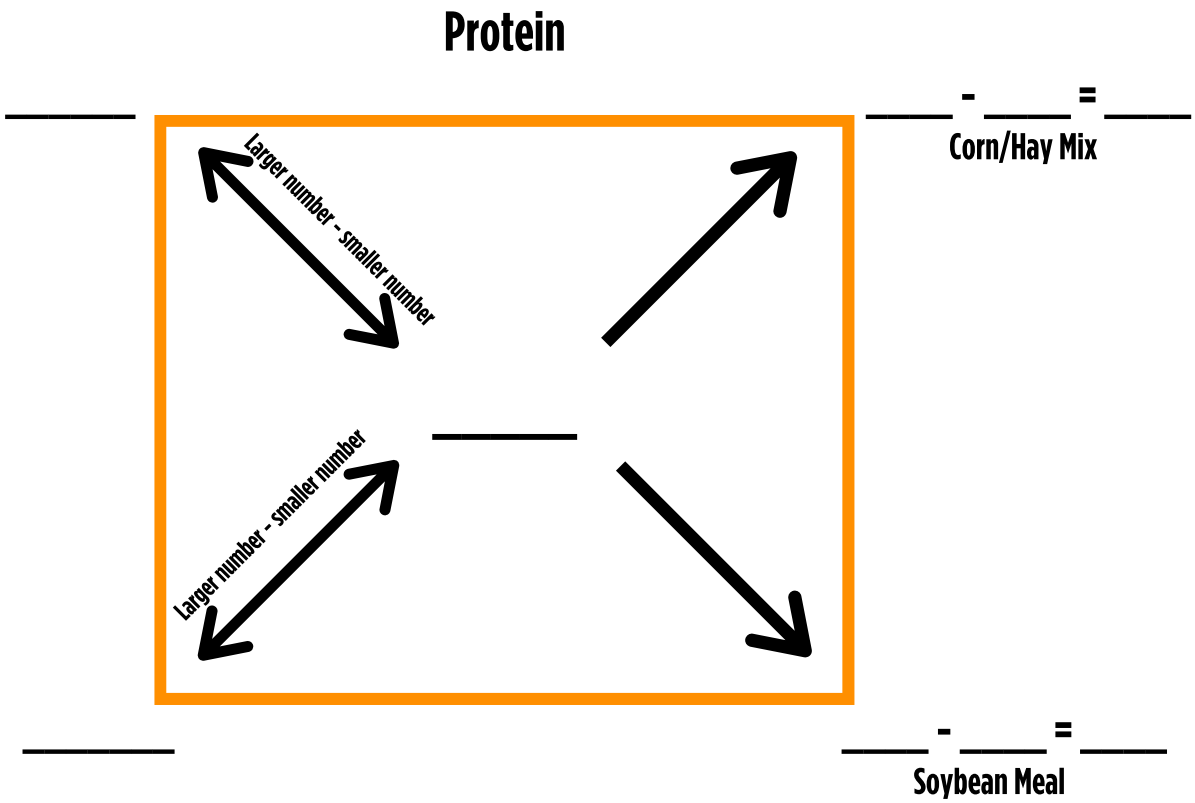
- Does the ration meet the requirement for crude protein? (Circle your answer)

Yes No

Step 5: Balance for Protein Supplement

Now we will balance for the protein supplement (soybean meal) that will be necessary to add to the ration to meet the protein requirement.

- We are going to use the Pearson Square method again.
  - In the top left corner, use the total protein from the ration that you calculated in the last step.
  - In the bottom left corner, use the crude protein found in soybean meal. This value is found in Table 2.



- Now that we have the parts for the ration, we will add them together to determine the total parts:
  - _____ parts steam flaked corn and barley hay mixture + _____ parts soybean meal = _____ total parts
- Next, divide the individual parts by the total parts:
  - _____ parts steam flaked corn and barley hay mixture / _____ total parts = _____% steam flaked corn and barley hay mixture
  - _____ parts soybean meal / _____ total parts = _____% soybean meal

Formulating Rations

Step 6: Determine the Pounds of Dry Matter Required

In this step, we will determine the number of pounds that we would need to feed the cattle on a dry matter basis. Remember, a "dry matter basis" means that we are working strictly with dried feeds, or feeds that have had all water removed.

- To find the pounds of dry matter required, use the Dry Matter Intake requirements found in Table 1 for the finisher ration.
    - The DMI requirement for the finisher ration is _____ lbs.

- Next, multiply the DMI requirement by the ingredient percentage (calculated in the last step).
    - _____ lbs DMI x _____ soybean meal (remember to turn your soybean meal percent into a decimal) = _____
    - This means that the animal must consume this many pounds of soybean meal per day.

- _____ lbs total DMI required - _____ lbs soybean meal required = _____ lbs remaining
- This requirement must be met with the steam flaked corn/barley hay mixture.

- To determine how much barley to use, multiply the remaining DMI by the ingredient percentage (calculated in Step 3).
    - _____ lb DMI required x _____ barley (remember to turn your barley percent into a decimal) = _____ lbs barley

- Now that we know the amount of barley we need to feed, we will calculate the amount of corn we need:
    - _____ lbs DMI required - _____ lbs barley = _____ lbs steam flaked corn

Step 7: Determine the Pounds As-Fed

In this step, we will determine the pounds "as-fed" for the ration. "As-fed" means the total weight of the ingredient in the real world, meaning that "as-fed" ingredients have not had water removed.

- To convert to as fed, divide the pounds of dry matter (calculated in the last step) by the percent dry matter (found in Table 2).
  - Don't forget to change your percents into decimals before calculating!

- Barley: _____ lbs DM / _____ % DM = _____ lbs barley
- Steam flaked corn: _____ lbs DM / _____ % DM = _____ lbs steam flaked corn
- Soybean meal: _____ lbs DM / _____% DM = _____ lbs soybean meal

These numbers represent the weight of each ingredient in the ration for one calf at the feedlot.

Step 8: Determine the Amounts of Each Ingredient for Batch Mixing

At the feedlot, rations are not prepared on a per-animal basis. Instead, they are created for entire pens of animals. Imagine that the feedlot just bought a pen of 300 cattle. They want to feed your finisher ration, and they want to know how much of each ingredient they need to add to mix enough ration for 300 cattle.

- To determine how much of each ingredient is required for 300 cattle, multiply the as-fed pounds (determined in the last step) for each ingredient by 300.
  - _ _____ lbs barley x 300 = _____ lbs barley
  - _____ lbs steam flaked corn x 300 = _____ lbs steam flaked corn
  - _____ lbs soybean meal x 300 = _____ lbs soybean meal

FINALLY! The Livestock Nutritionalist knows that in order to feed 300 cattle a finisher ration, they need to mix:

_____ lbs of barley,

_____ lbs of steam flaked corn, and

_____ lbs of soybean meal

Teacher Key

Grower

- Step 1:
  - Barley 57%
  - Corn: 93%
  - Requirement: 73.4%
- Step 2:
  - 19.6 parts barley
  - 16.4 parts corn
    - 36 total parts
- Step 3:
  - 54% barley
  - 46% corn
- Step 4:
  - 4.86% barley protein
  - 4.23% corn protein
    - 9.09% total crude protein
    - Does not meet the 12.1 % requirement
- Step 5:
  - 37.8 parts corn/barley
  - 3.01 parts soybean meal
    - 40.81 total parts
  - 92.6% corn/barley
  - 7.4% soybean meal
- Step 6:
  - DMI Requirement: 15.1 lbs
    - 1.1 lb soybean meal
    - 14 lb remaining
      - 7.56 lb barley
      - 6.44 lb corn
- Step 7:
  - 1.24 lb soybean meal
  - 8.4 lb barley
  - 7.58 lb corn
- Step 8:
  - 372 lb soybean meal
  - 2,520 lb barley
  - 2,274 lb corn

Finisher

- Step 1:
  - Barley 57%
  - Corn: 93%
  - Requirement: 61.3%
- Step 2:
  - 31.7 parts barley
  - 4.3 parts corn
    - 36 total parts
- Step 3:
  - 88% barley
  - 12% corn
- Step 4:
  - 7.92% barley protein
  - 1.1% corn protein
    - 9.02% total crude protein
    - Does meet the requirement
- Step 5:
  - Students will skip because added protein is not needed.
- Step 6:
  - DMI Requirement: 25.4
    - 22.352 lb barley
    - 3.05 lb corn
- Step 7:
  - 24.84 lb barley
  - 3.6 lb corn
- Step 8:
  - 7,452 lb barley
  - 1,080 lb corn

Creating a Device to Mix Feed

Currently, many devices exist to mix feed in large batches. However, these devices do not take advantage of a combined hardware-software system that can use computers to mix feed. This automates the process of mixing feed, which eliminates human error in the feed mixing process.

When a livestock nutritionist balances a ration, they come up with specific weights of each ingredient that must be utilized to meet animal requirements. If an error is made when the feed is being mixed, the following can happen:

- If an ingredient is mis-weighed, then added to a mixture, the TDN and crude protein content within the feed will not match the requirements that the livestock nutritionist balanced the ration to include.
- If too much of an ingredient is used, there is extra money spent on that ingredient that the feedlot owner didn't plan on spending. This can become very costly.
- If too little of an ingredient is used, the cattle on the feedlot may not gain weight as quickly as the feedlot owner planned. This can result in the cattle spending more time on the feedlot, because they have to be fed for a longer amount of time.

To help reduce human error when mixing feed, livestock nutritionists have suggested automating the process. To do this, they have worked with agricultural engineers and software developers to create a plan for a feed-mixing device. This device contains hardware that allows three different feed ingredients to be mixed together to create a ration. This hardware is made of physical components that can actually mix the feed together.

This device also contains software that will allow the livestock nutritionist to input ingredient weights. Then, the computer will tell the hardware how much of each ingredient to pour into each section of the mixer. Then, it will weigh the individual ingredients, then the ingredients together as a batch. Once the software confirms the correct weights, it will tell the hardware to mix the feed together.

The software will perform the following actions:

- Livestock nutritionist will balance the ration independently, then input the weights of each ingredient into the device
- Software must weigh each ingredient independently
    - Must know that the weight is correct, and what to do if it is not
    - Software must weigh total batch weight (all ingredients together)
    - Software must have notification processes to alert feedlot workers if there is a hardware problem

Creating Software

You will create an app that livestock nutritionists and feedlot owners will use. The app will be used to input ration ingredients and weights. Then, the hardware will mix the feed using this information.

Before an app is built, a wireframe is created. A wireframe is a series of images and words that describe what the app will look like and how it will function.

You will create an app that meets the following requirements:

- The app should have a screen where livestock nutritionists can select ingredients and input the ingredient weights for the ration. This screen should also include a spot to input the number of cattle being fed.
- The app should have a screen that shows a schematic of the device. This will be the diagnostic screen, where the device runs a self-check to ensure that all parts of the device are functioning normally.
    - After the livestock nutritionist navigates through these two screens, the mixing process will begin.
- The app should have a screen for livestock producers and feedlot owners to show the progress of the feed mixing and an estimated time of completion.
    - This screen should show the weights that the device calculated based on the livestock nutritionist's inputs.
    - This screen should show inventory levels—if the feedlot owner needs to order more of an ingredient, this screen needs to tell them inventory is low.
    - This screen should show the progress of the mixing process

In the box below, draw and label the screen where livestock nutritionists can input ingredients and weights:

Formulating Rations

STEM CAREER ADVENTURES

In the box below, draw and label the diagnostic screen:

In the box below, draw and label the progress screen:

Creating Hardware

In this step, you will create a prototype for the feed mixing device. Your device must have the following components:

- Three separate locations within a larger basin (each ingredient will have its own location)
- Three separate external bins that store each feed ingredient outside of the device
- A spot for a scale beneath each ingredient (so that each ingredient can be weighed individually)
- A spot for a scale beneath all three ingredients (so that the total weight of the ingredients can be weighed together)
- An attachment that pours the ingredient into each location
- An attachment that stirs the feed together to mix it
- Sensors in different locations to notify software if there is an issue with any hardware components

Use the space below to brainstorm ideas for your device: