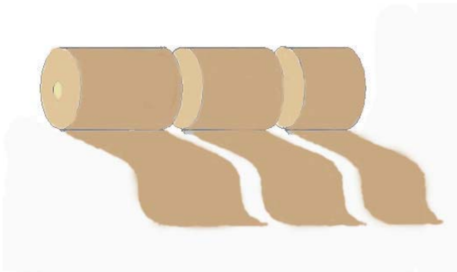

LINDO Cutting Stock Tool Kit

A common problem arising in the production of cable, film, paper, plastics, pipe, steel, textiles, wire, and wood trim, is how to cut a generic raw material, e.g., wide rolls of paper, into the narrower finished products demanded by customers. The number of each finished good size needed each day or week may vary dramatically.

If done carelessly, the scrap wasted from odd size remnant product may be higher than 10%. Experience has been that the scrap waste can be reduced to 1% or less by "being smart" when doing this cutting. The production process is fundamentally a joint product process. For a successful application, a variety of complications must be considered in addition to minimizing raw material costs: one does not want to use a wide variety of cutting patterns; details of sequencing of the cutting and due dates are important if there are many customers. If there are multiple machines or locations, there are issues of the allocation of demand to the most appropriate production facility.

Based on 15 years experience in the steel sections, paper, plastics, cable, and industrial products industries, LINDO systems has produced a comprehensive software tool kit for solving cutting stock problems. Some of the considerations that may be taken into account with these tools, in addition to simply minimizing the cost of raw materials are:

1. *Min pattern changes or Fixed cost of setting up a particular pattern*. This cost consists of lost machine time, labor, etc. This motivates solutions with few patterns.
2. *Machine usage cost*. The cost of operating a machine is usually fairly independent of the material being run. This motivates solutions, which cut up wide raw material widths, even if different sizes have the same cost/unit.
3. *Multiple machines*. In some applications there is an assignment problem on top of the cutting stock problem. That is, one must decide upon which machine to cut each pattern, based on such things as efficiency of each machine and available capacity.
4. *Multiple raw materials*. In many applications one can obtain the raw material in various sizes, with the larger sizes frequently being cheaper per unit. The drawback of the larger size may be that one may be forced to buy in larger quantities, perhaps leading to more left over.
5. *Remnant inventory/Limited raw material availability*. In some situations, you may put leftover raw material from one day into inventory to be used on a later day. Thus, your cutting stock solver must be able to choose among different raw material sizes when solving a given day's problem. Also, when choosing among cutting pattern solutions, even though two solutions may use the same amount of raw material, you generally will prefer the solution

that leaves one large size of remnant or leftover material as opposed to the solution that leaves two small sizes of leftover material.

6. *Overage and Underage costs*. For example, there may be some demand next period for a modest amount of excess cut this period. Specifying a modest value for a modest amount of overage of finished product today provides a way of managing remnant inventory. Alternatively, in some industries or markets, order quantities are considered “nominal” plus or minus, say 10%. So an order for 1000 units effectively says the supplier must supply at least 900 units but at most 1100 units. The supplier may charge according the actual quantity delivered. For example, If the supplier has two orders, one for 1000 units, the other for 820 units, and of such sizes that one unit of each of the two products together exactly use up one raw material size, then the supplier will probably want to cut 902 units of each(820 + 82 and 1000 – 98).
7. *Material specific products*. It may be impossible to run two different products in the same pattern if they require different materials (e.g., different thickness, quality, surface finish or type).
8. *Upgrading costs*. It may be possible to reduce setup, edge-waste and end-waste costs by sometimes substituting a higher grade material than required for a particular demand width.
9. *Order splitting costs*. If a demand width is produced from several patterns, then there will be consolidation costs due to bringing the different lots of the output together for shipment.
10. *Stock width change costs*. A setup involving only a pattern change usually takes less time than one involving both a pattern change and a raw material width change. This motivates solutions that use few raw material widths.
11. *Minimum and maximum allowable edge waste*. For some materials, a very narrow ribbon of edge waste may be very difficult to handle. Therefore, one may wish to restrict attention to patterns that have either zero edge waste or edge waste that exceeds some minimum, such as two centimeters. On the other hand, one may also wish to specify a maximum allowable edge waste. For example, in the paper industry, edge waste may be blown down a recycling chute. Edge waste wider than a certain minimum may be too difficult to blow down this chute.
12. *Due dates and sequencing*. Some of the demands need to be satisfied immediately. Whereas, others are less urgent. The patterns containing the urgent or high priority products should be run first. If the urgent demands appear in the same patterns as low priority demands, then it is more difficult to satisfy the high priority demands quickly.
13. *Inventory restrictions*. Typically, a customer’s order will not be shipped until all the demands for the customer can be shipped. Thus, one is motivated to distribute a given customer’s demands over as few patterns as possible. If every customer has product in every pattern, then no customer’s order can be shipped until every pattern has been run. Thus, there will be substantial work in process inventory until all patterns have been run.
14. *Limit on 1-set patterns*. In some industries, such as paper, there is no explicit cost associated with setting up a pattern, but there is a limit on the rate at which pattern changes can be made. It may take about 15 minutes to do a pattern change, much of this work being done off-line without shutting down the main machine. The run time to produce one roll set might take 10

minutes. Thus, if too many 1-set patterns are run, the main machine will have to wait for pattern changes to be completed.

15. *Max cuts or products per pattern*. In some applications, there may be a limit on the total number of final product widths that may appear in a pattern. This restriction may apply, for example, if there are a limited number of take-up reels for winding up the slit finished products.
16. *Max "smalls" per pattern.* There may be a limit on the number of "small" widths in a pattern. This restriction might be encountered in the paper industry where rolls of narrow product width have a tendency to fall over, so one does not want to have too many of them to handle in a single pattern.
17. *Product positioning.* Some demanding customers may request that their product be cut from a particular position (e.g., the center) of a pattern, because they feel the quality of the material is higher in that position.
18. *Pattern pairing*. In some plastic wrap manufacturing, the production process, by its nature, produces two widths of raw material simultaneously, an upper output and a lower output. Thus, it is essentially unavoidable that one must run the same number of feet of whatever pattern is being used on the upper output as on the lower output. A similar situation sometimes happens by accident in paper manufacturing. If a defect develops on the "production belt", a small width of paper in the interior of the width is unusable. Thus, the machine effectively produces two output widths, one to the left of the defect, the other to the right of the defect.
19. *Bundle size*. In some markets you may be forced to buy product in bundles of a given size, e.g., 10 pieces per bundle. Further, you may be forced to make cuts in bundles rather than in individual pieces. Thus, even though you have a demand of 15 units for some finished good, you are forced to cut at least 20 units because the bundle size is 10.
20. *Saw thickness*. If the material is sawed rather than sheared, each saw cut may remove a small amount of material, sometimes called the kerf. Precise solution of a cutting stock problem should take into account material lost to the kerf.

An off-the-shelf version is available for simple, straightforward applications. This standard version requires the following input:

1) Number of raw material types,
2) Length, cost per unit, number units available of each raw material,
3) Number of finished good types,
4) Length, number units required of each finished good type.

The solution will specify the cutting patterns to use, and how many sets to run of each so as to minimize the cost of raw material.