Resource 1 - How many employees?

Age group	14 and above
Time	1 hour
Subject	Maths

National Curriculum links

England Key stages 3 and 4

Working mathematically - Solve Problems:

- develop mathematical knowledge, in part through solving problems and evaluating the outcomes, including multi-step problems
- develop use of formal mathematical knowledge to interpret and solve problems, including in financial contexts
- model situations mathematically and express the results using a range of formal mathematical representations, reflecting on how their solutions may have been affected by any modelling assumptions
- select appropriate concepts, methods and techniques to apply to unfamiliar and non-routine problems; interpret their solution in the context of the given problem

Skills developed

- **Representing:** Simplify information given, make assumptions, decide upon a strategy to solve a problem.
- **Analysing:** Identify information and assumptions to use in a strategy to produce a solution.
- **Communicating:** Present solutions including limitations and alternative solutions summarising conclusions.
- **Reflecting:** Comment on the validity of results.

Overview of Packing Problems resources

Packing problems are an example of an optimisation problem based in a real-life context. Throughout the curriculum students will be asked to solve problems in such a manner to find the greatest or least solution. In higher study, students will use graphical methods and calculus to solve such problems. Packing problems, sometimes referred to as bin packing problems, are an accessible gateway to this kind of study. Once students are familiar with simple algorithms they are able to compare and contrast different solutions and explain the merits, or otherwise, of each solution. These problems are set in realistic situations, hence students are required to analyse their mathematical solution to determine whether this solution is valid in the real-life context and students are introduced to the concept of mathematical modelling.

It is recommended students attempt the resources in the following order. However, they can be done on a stand-alone basis.

1. How many employees?
2. How many parcels?
3. Shelving

Resource Overview - 1 - How many employees?

This resource includes these items:

- Teacher notes.
- Student activity sheet setting out the task and giving the information required for the students.
- Fact sheet with relevant information.
- Exemplar solutions which teachers may use to support groups of students who need some scaffolding to get started.
- Presentation slides to help explain the tasks.

The context

In this problem a manager has a number of jobs which need to be allocated to employees. Each job takes a certain amount of time. The constraints are each employee can work a maximum of 30 hours and each job must be completed by one person, i.e. a job cannot be split between two people.

Student tasks

Task One: Students are told that one employee thinks 4 people will be needed. Students have to explain whether they think this answer to the problem is correct or not, and justify their reasoning.

Task Two: Students are asked to use a first fit algorithm to schedule the jobs.

Task Three: Students are asked to use a first fit decreasing algorithm to schedule the jobs. Students then need to reflect upon which method was better.

Supporting notes

Students may be given the first problem and asked to decide, and explain, how they will go about solving the problem. As an introduction, it is recommended that students be advised to produce a simple grid upon which to work. Examples of these can be seen in the accompanying presentation slides.

The tasks presented ask students to use first fit and first fit decreasing algorithms and the slides provide a step-by-step guide to the first fit algorithm method and solutions for both the first fit and first fit decreasing algorithm methods.

To extend the activity students could be asked to use a full bin algorithm. A solution can be found on the solution sheet.

Bin Packing Algorithms

There are three basic bin packing algorithms to which students may be introduced:

1/ First fit algorithm

The first fit algorithm is a very simple algorithm which is easy to perform. Given a number of 'bins' numbered 1,2,3… and a number of tasks A,B,C…

- Task A is allocated to bin 1.
- Task B is allocated to bin 1 if possible. If not task B is placed in bin 2.

- Task C is allotted to bin 1 if possible. If not, task C is allocated to bin 2. If task C cannot go into bin 2 it is added to bin 3.

Each task is taken in turn and allocated to the first bin in which it will fit, always starting at bin 1.

This algorithm is easy to perform and easy to program a computer to perform but does not always produce an optimal solution.

2/ First fit decreasing algorithm

This algorithm is very similar to the first fit algorithm. Before starting to perform the first fit algorithm, arrange the tasks in order of size, starting with the largest task. Once ordered, perform the first fit algorithm on the tasks in their descending order.

This algorithm is easy to perform and easy to program a computer to perform. The first fit decreasing algorithm tends to give better results than the first fit algorithm.

3/ Full bin algorithm

The tasks, jobs or items are arranged into groups with the aim of producing as many full bins as possible. For example, in the problem 'How many employees?' students are asked to arrange the jobs in such a way that as many groups as possible have jobs whose length adds up to 30 hours. Each of these groups, or 'bins' is then allocated to each of the employees.

The full bin algorithm is not a very efficient method. With a lot of items to match up the task can be time-consuming, and it is difficult to determine whether an optimal solution has been found. It is also very challenging to program a computer to carry out the full bin algorithm.

Mathematics National Curriculum - England

Whilst bin packing problems do not feature specifically in the National Curriculum in England, there are many references to students being required to solve problems, model mathematically and for the use of mathematical reasoning in solving problems in a real-life context.

The aims of the National Curriculum for KS3 and KS4 in England states that students should be able to:

'…solve problems by applying their mathematics to a variety of routine and non-routine problems with increasing sophistication, including breaking down problems into a series of simpler steps and persevering in seeking solutions'.

Generation Logistics Education Hub

This resource is one of the many engaging resources available from Generation Logistics on their Education Hub. For more details go to: www.educationhub.generationlogistics.org/