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1. We are excavating an area for a road pavement with a hydraulic excavator which has a bucket capacity of $0.6m^3$. The operation (excavation and emptying the bucket lasts 45 seconds on average. The dumper trucks we are using has a $30m^3$ capacity. How much time do we need to fill the dumper truck?

Bucket capacity: $0.6m^3$
 Excavation operation time: 45s
 Dumper capacity: $30m^3$

How many buckets to fill one dumper? $\frac{\text{dumper capacity}}{\text{bucket capacity}} = \frac{30m^3}{0.6m^3} = 50$

How much time for this operation? $50 \times 45s = 2250s$
 $= \frac{2250}{60} \text{min} = 37.5\text{min}$

2. We have to dump this soil 20km away. If the average velocity of the dumper truck is 30km/h and the tipping time is 3 minutes, how much time do we need to complete a cycle of the dumper truck?

Distance: 30km
 Velocity of dumper: 30 km/h

How long does it take to get to the dump site? $\frac{\text{distance}}{\text{speed}} = \frac{20\text{km}}{30\text{km/h}}$
 $= \frac{2}{3} \text{hours} = 40\text{min}$

Add the tipping time and the return journey $40 + 3 + 40 \text{ min}$
 $= 83\text{min}$

3. If we are to optimise this operation, how many dumper trucks do we need for the hydraulic excavator to have continuous operation?

Excavator operation takes: $37.5min$

Dumper operation takes: $83min$

So, for $83min - 37.5min = 45.5min$ the excavator is sitting idle.

Optimisation means getting the best use of both the equipment. Imagine if we had another dumper, when the first one is filled in $37.5min$ and departs, the second dumper can start to fill-up, which will take another $37.5min$.

When the second dumper departs, it will be $75min$ since start, but the first dumper is still $83min - 75min = 8min$ away.

Mathematically therefore, we need: $\frac{83min}{37.5min} = 2.213$ dumpers

Realistically therefore we need 3 dumpers, but with the understanding that as the third dumper gets filled, the first dumper will return and wait. It's a decision that should be made based on the operational cost of each of this equipment.

If the idle cost of the excavator for 8 minutes is higher than the idle cost of a dumper truck sitting $37.5min - 8min = 29.5min$ then we should have 3 dumpers, otherwise 2 dumpers.