How much soil and rock needs to be excavated?

METROTUNNEL Education Program

Our stations

North Melbourne

Parkville

State Library

Town Hall

Anzac

North Melbourne 1

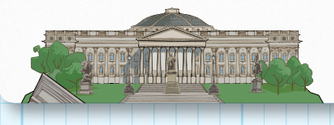
Height: 16 m
Width: 72 m
Length: 100 m
Volume:
m³

Parkville 2

Height: 27 m
Width: 69 m
Length: 110 m
Volume:
m³

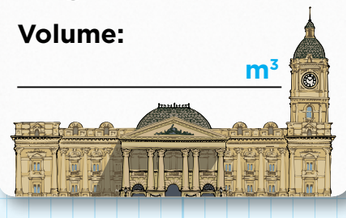
State Library 3

Height: 37 m
Width: 51 m
Length: 103 m
Volume:
m³



Town Hall 4

Height: 28 m
Width: 80 m
Length: 80 m
Volume:
m³

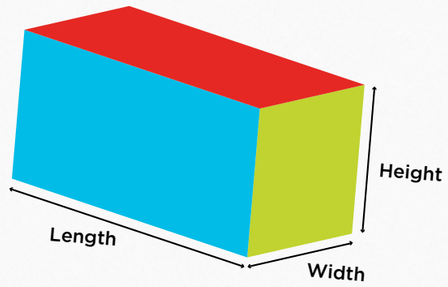


Anzac 5

Height: 15 m
Width: 62 m
Length: 120 m
Volume:
m³

Calculating the volume of rectangular prisms

Height x Width x Length



Volume is measured in m³

Now work out the volume of the tunnels...

Your team:

Notes:

Note: All dimensions provided are indicative for educational purposes only.

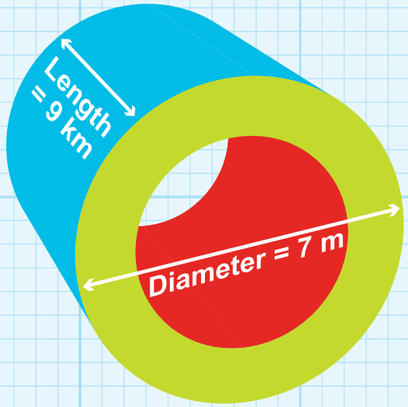
How much soil and rock needs to be excavated?

METROTUNNEL Education Program

Our tunnels

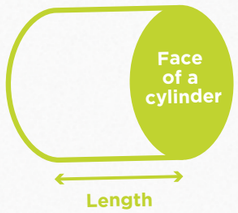
Remember

There are **two** tunnels, one in each direction!



Working it out

A tunnel is basically a large cylinder. The volume of a cylinder is found by multiplying the area of the face (a circle) by the length of the cylinder.



Pi (π) is used to calculate the area of the face. Pi is the ratio of a circle's circumference to its diameter. Regardless of the size of the circle, Pi is always the same number, approximately 3.14.

Area of face = Pi (π) x radius²

Or:

Area of face = 3.14 x R x R

Volume of cylinder =
Area of face x Length of cylinder

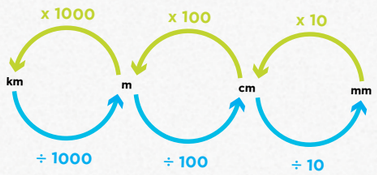
Or:

Volume of cylinder = πr² x L

Note: The area and volume are in metres

The length of the tunnel is in kilometres

Converting units of length



Find the radius

Radius = Diameter ÷ 2

Radius = _____ m

Area of the TBM face

Show your working out

Area = _____ m²

Volume of the tunnels

Show your working out

Total volume of tunnels _____ m³

About the Tunnel Boring Machine

Four giant Tunnel Boring Machines (TBMs) are needed to dig the Metro Tunnel.

BIG AND BEAUTIFUL
At 120 m long, the TBMs are as long as 3 E-Class trams end-to-end. They weigh a whopping 1,100 tonnes, equal to the weight of around 150 elephants.

ROCK AND ROLL
TBMs bore through a variety of ground conditions from hard rock to sand, and travel around 10 m a day. The amount of excavated material removed would fill the MCG 1.2 times!

HEAVE-HO
Up to 14 people work in each TBM at any one time. Workers in the TBM include the operator, who drives the TBM, as well as tunnel and electrical engineers.

HOME SWEET HOME
Each TBM is manned and monitored 24 hours a day, 7 days a week. It is fully equipped with facilities for staff, including an office, kitchen and toilets.

What is the total volume of all the stations and tunnels?

North Melbourne + Parkville + State Library + Town Hall + Anzac + Tunnels = ??? m³

_____ + _____ + _____ + _____ + _____ + _____ = _____

Note: All dimensions provided are indicative for educational purposes only.

The logistics of soil and rock removal

METROTUNNEL Education Program

Truck 1 10 metre tipper

Haulage:
Capacity: **12 m³**
Maximum journeys per day: **8**

Daily costs:
Fuel: **$460**
Driver wages: **$392**
Maintenance: **$63**

Key features

- Lightweight – can travel on **ALL** roads.
- Nimble – can access all sites, get through traffic lights quicker and travel at designated speed limits.
- Accessible – more drivers available as no special licence required.
- Readily available – project can scale operations up and down with greater ease.
- Smaller capacity – more trips per day to transport load.
- More trips = more emissions, increased pollution and more road congestion.

Should we use Truck 1?

1. How much excavated material can this truck remove in one day?

Truck Capacity x Maximum number of trips in one day = Amount of soil and rock for one day

_____ x _____ = _____ m³

2. The project requires 3,000 m³ of excavated material to be removed per day to meet construction deadlines.

This truck can remove _____ m³ per day.

How many trucks will you need?

Amount of excavated material to be removed per day ÷ Amount of soil and rock removed by one truck in one day = Number of trucks needed.

_____ m³ ÷ _____ m³ = _____ trucks

3. How much will it cost to run one of these trucks per day?

Use the information above and the truck facts to answer this question:

Driver wages: $ _____

Truck maintenance cost: $ _____

Fuel cost: $ _____

Total cost for one truck per day: $ _____

Total cost to remove the 3,000 m³ of excavated material per day:

Cost of one truck x Number of trucks needed each day = Total cost per day

$ _____ x _____ = $ _____

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The logistics of soil and rock removal

METROTUNNEL Education Program

Truck 2 Semi Tipper

Haulage:
Capacity: **30 m³**
Maximum journeys per day: **4**

Daily costs:
Fuel: **$600**
Driver wages: **$490**
Maintenance: **$78**

Key features

- Can carry large loads and make frequent trips.
- Larger capacity = longer to load and unload.
- This truck is not affected by road weight limits; however, its length and size restrict access to some sites such as those with narrow streets.
- Specialised license required = fewer qualified drivers available and higher wages.
- Heavier truck – takes longer to accelerate up to speed. It is restricted by speed limits applicable to heavier loads, making travel times longer.
- Fewer trucks = less emissions, less pollution and less road congestion.

Should we use Truck 2?

1. How much excavated material can this truck remove in one day?

Truck Capacity x Maximum number of trips in one day = Amount of soil and rock for one day

_____ x _____ = _____ m³

2. The project requires 3,000 m³ of excavated material to be removed per day to meet construction deadlines.

This truck can remove _____ m³ per day.

How many trucks will you need?

Amount of excavated material to be removed per day ÷ Amount of soil and rock removed by one truck in one day = Number of trucks needed.

_____ m³ ÷ _____ m³ = _____ trucks

3. How much will it cost to run one of these trucks per day?

Use the information above and the truck facts to answer this question:

Driver wages: $ _____

Truck maintenance cost: $ _____

Fuel cost: $ _____

Total cost for one truck per day: $ _____

Total cost to remove the 3,000 m³ of excavated material per day:

Cost of one truck x Number of trucks needed each day = Total cost per day

$ _____ x _____ = $ _____

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The logistics of soil and rock removal

METROTUNNEL Education Program

Truck 3 Truck and Dog

Haulage:
Capacity: **60m³**
Maximum journeys per day: **3**

Daily costs:
Fuel: **$1,050**
Driver wages: **$574**
Maintenance: **$119**

Key features

- Biggest capacity – best for large volumes of excavated material over long distances.
- Fewer trucks required to shift the excavated material = less emissions.
- Specialised license required = fewer qualified drivers available and higher wages.
- Can't access built-up areas due to size and weight of truck and huge turning circle.
- Big trucks take more time and distance to both accelerate and slow down, so freeways with less stop-start traffic or sharp bends are better routes.
- Pick up sites close to major highways tend to have bigger entrances and exits. There is usually less residential development, road congestion and pedestrian traffic in these areas.

Should we use Truck 3?

1. How much excavated material can this truck remove in one day?

Truck Capacity x Maximum number of trips in one day = Amount of soil and rock for one day

_____ x _____ = _____ m^3

2. The project requires 3,000 m^3 of excavated material to be removed per day to meet construction deadlines.

This truck can remove _____ m^3 per day.

How many trucks will you need?

Amount of excavated material to be removed per day ÷ Amount of soil and rock removed by one truck in one day = Number of trucks needed.

_____ m^3 ÷ _____ m^3 = _____ trucks

3. How much will it cost to run one of these trucks per day?

Use the information above and the truck facts to answer this question:

Driver wages: $ _____

Truck maintenance cost: $ _____

Fuel cost: $ _____

Total cost for one truck per day: $ _____

Total cost to remove the 3,000 m^3 of excavated material per day:

Cost of one truck x Number of trucks needed each day = Total cost per day

$ _____ x _____ = $ _____

Note: All dimensions provided are indicative for educational purposes only.