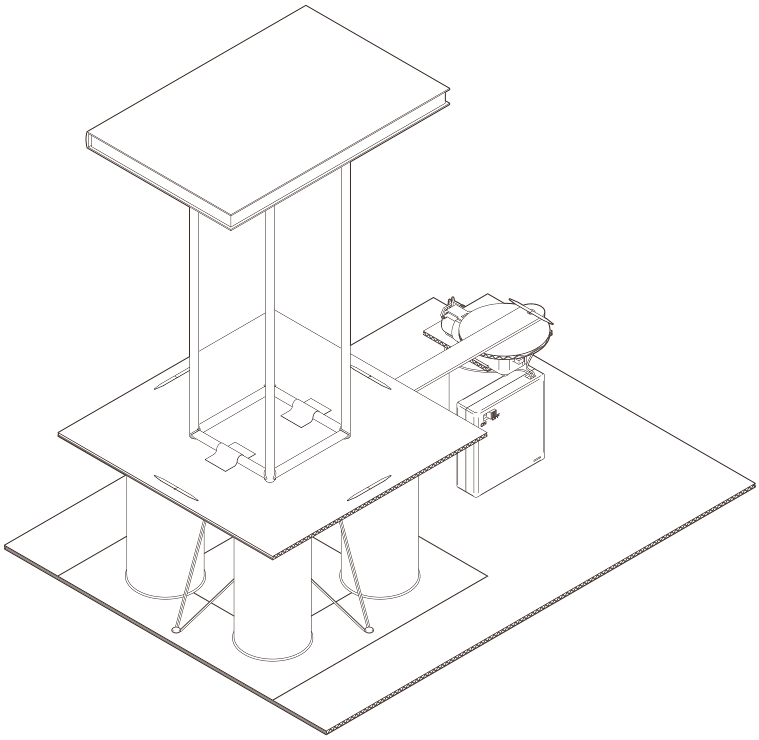


SEISMIC SHAKER WORKSHEET

GETTING STARTED

5-10m

Did you know that in places around the world where earthquakes are common, engineers can be lifesavers?

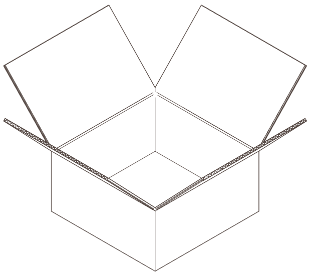
Today, hundreds of millions of people live in earthquake-prone areas. By designing structures that can withstand the force of earthquakes, engineers provide these people with safe surroundings.

For testing purposes, engineers build shake tables to simulate the motion caused by seismic waves during an earthquake. Some shake tables are large enough to put a full-size building on; others are smaller, for testing models and components.

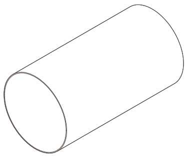
This session will show you how to build a model shake table which you can use to test and develop your designs for earthquake-resistant structures.

This activity is best suited to more advanced students aged 9+ with the supervision of a teacher or adult.

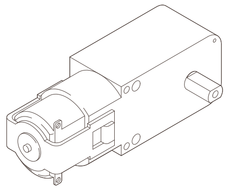
YOU WILL NEED



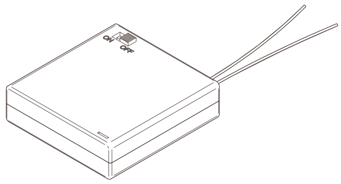
Cardboard Box
1
40cm in length



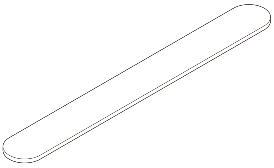
Cardboard Tubes
5
10cm in height



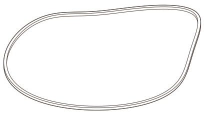
Geared Motor
1



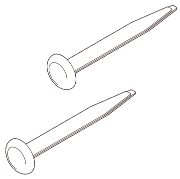
Four AA Battery Pack
1



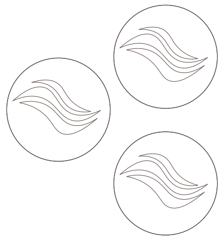
Large Lolly Stick
1



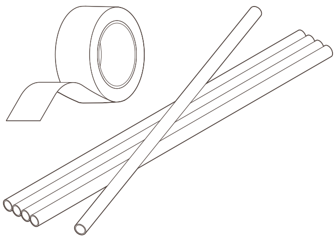
Elastic Bands
8



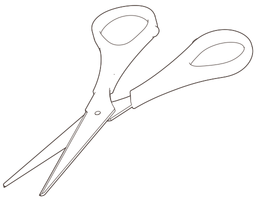
Split Pins
9



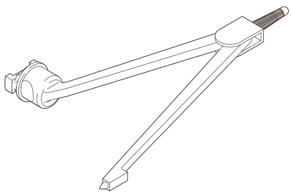
Marbles
4



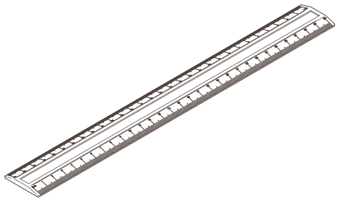
Tower Construction Materials (straws, tape or building blocks)



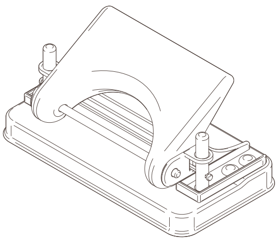
Scissors
1 Pair



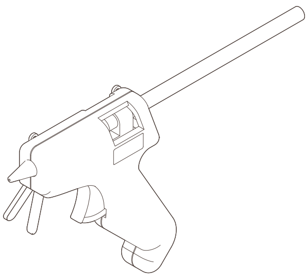
Compass
1



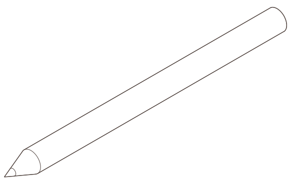
Ruler
1



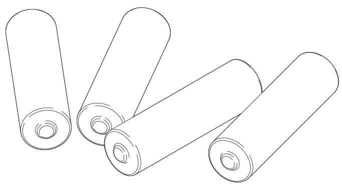
Hole Punch
1



Glue Gun
1



Pencil
1



AA Batteries
4

VOCABULARY

Diameter - The length of the line through the centre of a circle that touches two points on the edge.

Compass - An instrument with two arms, one sharp and one with a pencil that can be used to draw circles or arcs.

Rotary Motion - The movement of an object in a circular motion.

Linear Motion - When an object moves in a straight line.

Circuit - A complete path around which electricity can flow.

Seismic Waves - Waves of energy that travel through Earth's layers as a result of earthquakes or volcanic eruptions.

Tectonic Plates - Enormous sections of Earth's crust which roughly fit together.

Plate Boundaries - The edges where two tectonic plates meet.

WARM-UP ACTIVITIES

A

5-10m

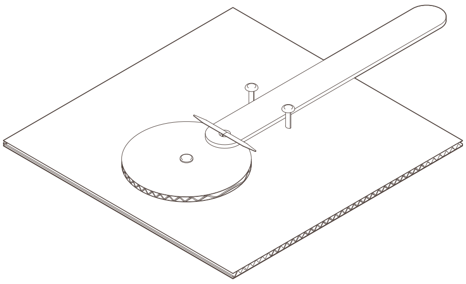
The shake table design uses a crank mechanism to transfer rotary motion, provided by the motor, to the linear motion, which shakes the table.

Before you begin the build, experiment with the effect of a crank linkage. Connect the card disc (crank) and lolly stick (rod) with a split pin. Then mount them onto a piece of card with three further split pins.

Consider and investigate the following:

- What happens when you connect the rod in different places?
- What happens when you change the size of the cadboard crank?

Continue to experiment with cranks and rods to explore the different types of motion you can create.



B

10-15m

The Pacific Ring of Fire is an earthquake belt that experiences 80% of the largest earthquakes in the world. Structures built in these areas have to be designed carefully, with this in mind.

Research online to find photographs of buildings built in The Ring of Fire. You might like to look at:

- The Transamerica Pyramid - USA
- The Yokohama Landmark Tower - Japan
- Beijing National Stadium - China

Look at the shapes, building materials used and any special features added.

Investigating existing earthquake-resistant buildings will give you some inspiration for designing your own.

MAIN CHALLENGE

1h

Designing and testing earthquake-resistant structures is a great way to develop your skills using the Engineering Design Process to solve problems.

It will also give you some insight into the important work engineers do, designing solutions that keep people living in earthquake zones safe.

Every time an engineer is faced with a problem, they approach it using the Engineering Design Process:

Ask - What's the problem?

Imagine - Choose a solution.

Plan - Design and choose materials.

Create - Make it.

Test - Test your creation.

Improve - Redesign as needed.

Using this design process, see if you can create a tower which:

- Is at least 25cm tall.
- Has a base no wider than 12cm.
- Is able to hold the weight of a book.
- Can withstand 30 seconds of shaking on the shake table.

We have provided you with an example of how to build the shake table and suggested some materials to use, but if you are feeling creative we encourage you to design your own.

Once your shake table is complete you can start to design and test earthquake resistant structures using ideas from your earlier research.

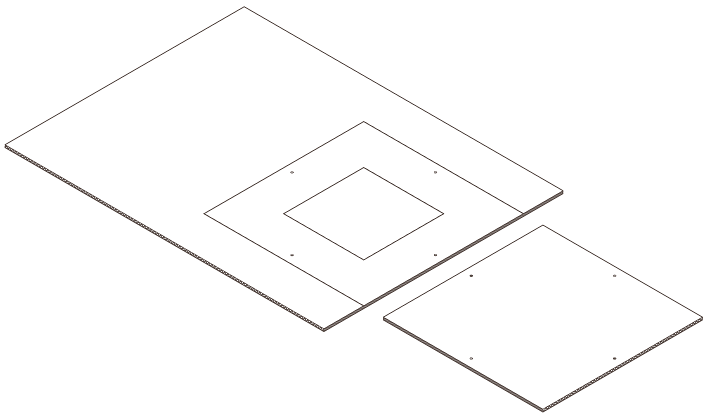
Good luck!

BUILDING THE SHAKE TABLE

Follow these steps to build a shake table, which can be used to test earthquake resistant structures.

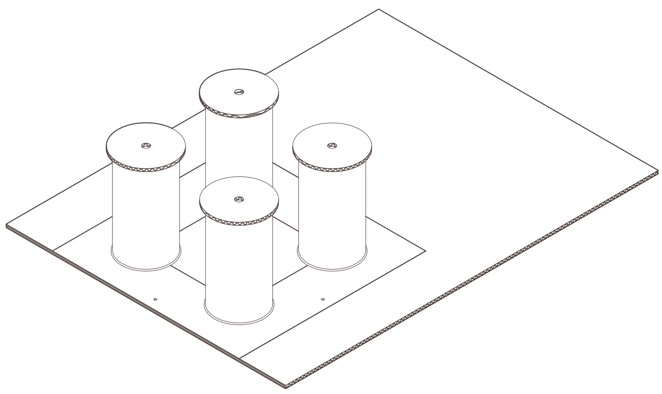
A

First, cut out a 40cm by 30cm base and a 20cm by 20cm tabletop from corrugated cardboard. At one end of the base, draw a 20cm by 20cm square with a 10cm by 10cm square in the middle. Then, make some holes for the split pins, which will help to hold the shake table together. Use a sharp pencil to pierce a hole in the middle of each side of the tabletop and along the middle of each line of the 20cm by 20cm square on the base.



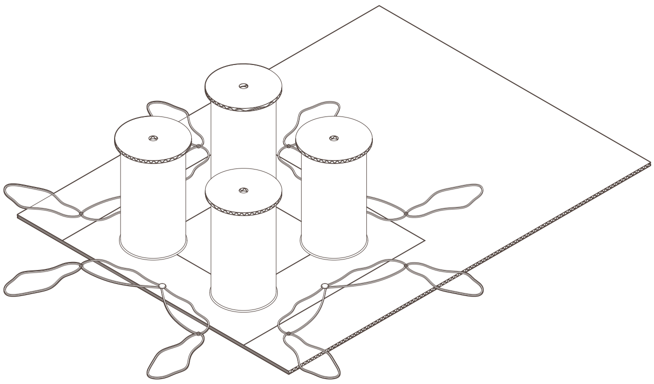
B

Next, make the legs for the shake table. Use a compass to draw four circles with a 6cm diameter. After cutting them out, use a pencil to make a hole (slightly smaller than the diameter of a marble) in the centre of each one. Then, glue the discs on top of the cardboard tubes. To finish the legs, glue one on each corner of the 10x10cm square drawn on the base.



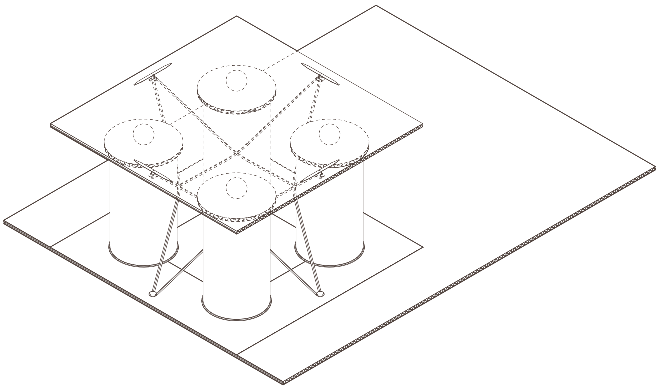
C

To connect the base to the table, push slit pins through the holes around the 20cm by 20cm square and secure them by folding the arms flat against the cardboard. Join pairs of elastic bands together to make a band roughly 16cm long. Then, hook the ends of two bands onto each of the split pins.



D

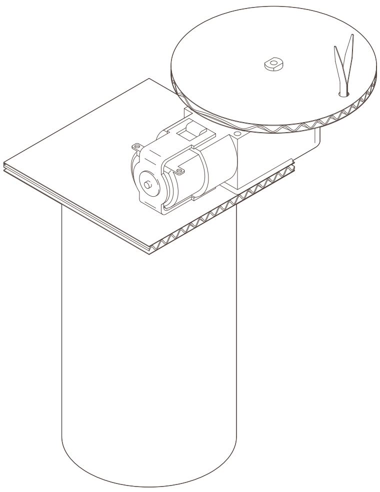
Next, push split pins through the holes around the edge of the tabletop. Then, hook the other end of each band, connected to the base, around one of the table top pins on the adjacent side of the square. Continue around the whole square so that all pins have two bands hooked over them. To complete the table, slide the four marbles under the tabletop so they sit in the holes made in the discs on top of each of the legs.



E

Build a tower for the motor by glueing a small square of cardboard to the top of a tube. Attach one side of the motor to the card square using hot glue.

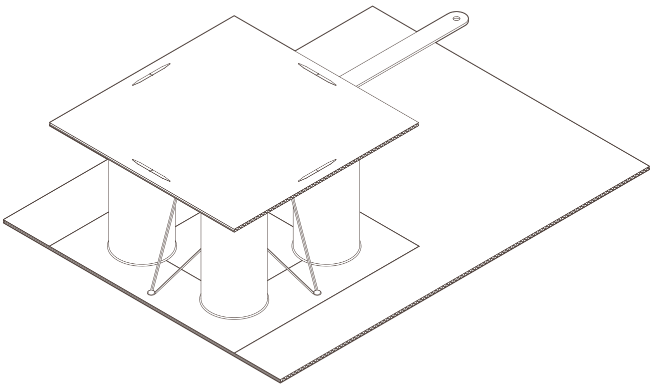
Use the compass to draw a 6cm diameter circle. Cut out the disc and make a hole near the edge with a hole punch. Push a split pin through the hole. Then, glue the disc to the arm of the motor.



F

To connect the motor and tabletop, use a hole punch to make a hole in one end of a lolly stick. Then, glue 2cm of the other end of the stick to the underside of the table.

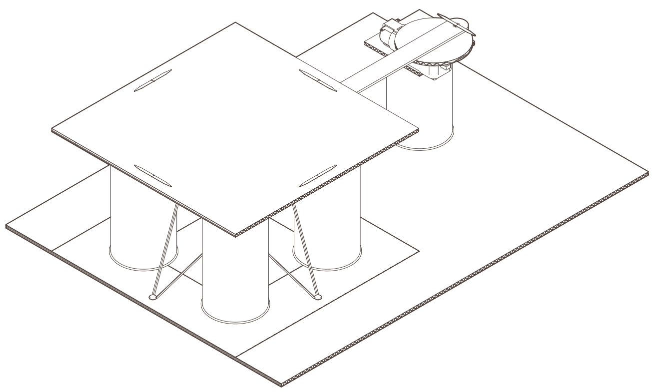
The disc and lolly stick form a crank mechanism that transforms the rotary motion from the motor to a linear motion that will shake the table.



G

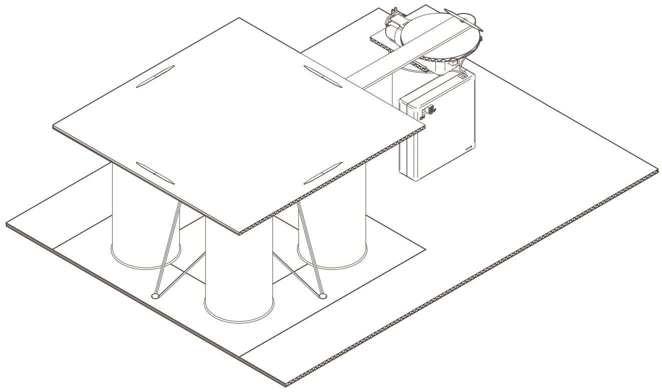
Glue the motor tower to the base, making sure the distance between the table and the tower accommodates the movement of the lolly stick (it will move to the opposite edge of the cardboard disc as it rotates).

Attach the lolly stick to the cardboard disc, by pushing the split pin through the hole in the stick and folding the arms flat against it.



H

The motor and battery pack will provide the power for the shake table. To create a complete circuit, electricity needs to travel from the batteries to the motor without any breaks. Carefully, wrap the ends of the wires from the battery pack to the copper connections on the motor, making sure the metal part of the wire is in good contact with the copper.



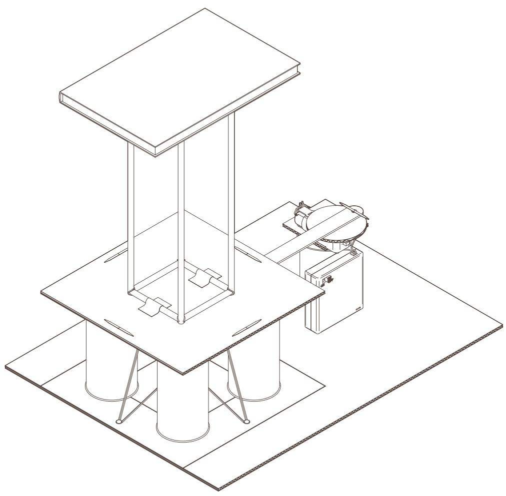
I

Your Seismic Shaker is now ready to test earthquake-resistant structures!

Remember that the structures must:

- Be at least 25cm tall.
- Have a base no wider than 12cm.
- Be able to hold the weight of a book.
- Be able to withstand 30 seconds of shaking on the shake table.

Once the structure is ready to test, it can be attached to the tabletop using two pieces of tape.



DID YOU KNOW?

Almost 80% of all the planet's earthquakes occur along the rim of the Pacific Ocean, called the "Ring of Fire" - a region that encircles the Pacific Ocean and is home to 452 volcanoes.

SEISMIC SHAKER

ENGINEERING FOR EARTHQUAKES

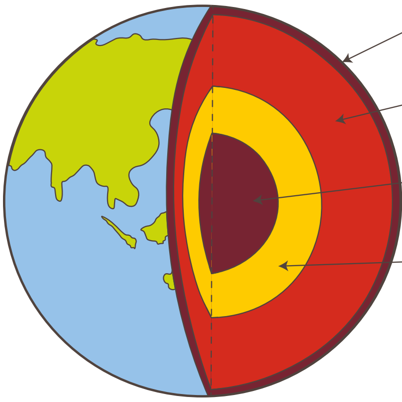
10-15m

KS 2/3
UNDERSTAND THE SCIENCE

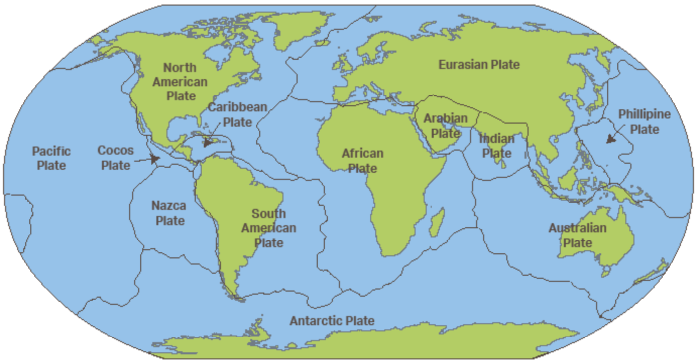
What are Earthquakes?

The Earth is made up of different layers:

- **Inner Core** - A huge metal ball, which despite being between 5,000°C to 6,000°C, stays solid because of the incredible pressure surrounding it.
- **Outer Core** - A layer of iron and nickel in liquid form that flows around the inner core.
- **Mantle** – The thickest layer, made of semi-molten rock called magma.
- **Crust** – A thin layer of rock covering the surface.



The Earth's surface is split into huge slabs made from the rocky crust and the upper parts of the mantle. These are called tectonic plates. They fit together like a jigsaw puzzle and move around at a rate of a few centimetres a year. Most earthquakes occur at plate boundaries, the zones where two, or more, plates meet.



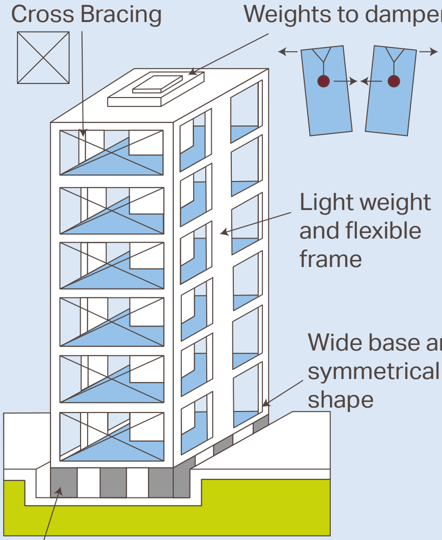
The edges of tectonic plates are jagged and rough. This means that when they push and grind past each other, they generate lots of friction and blocks of rock can sometimes become locked together. When this happens, the energy that would normally cause the blocks to move past each other is stored up. Eventually, the stress builds up so much that the plates suddenly jolt into a new position. This movement releases energy which travels through the Earth as seismic waves, shaking the surface, along with anything on it. This is an earthquake.

There are thousands of earthquakes across the world each day. Some are so small that they can only be detected by specialist equipment. Others can be so intense that they can create lots of damage and destroy towns and cities.

KS 3/4
DEEPER LEARNING

Building Design

Engineers use innovative design features to help prevent damage to buildings during earthquakes:



Reinforcement

The building can be reinforced with cross braces. These diagonal supports in an X-shape help to provide strength and stop the building twisting.

Shock Absorbers

Rubbery devices are installed near the foundation of the building to absorb energy from the seismic waves. The flexible pads, made of steel and rubber, lift the building above ground so that only the base moves while the structure remains steady.

Lightweight Materials

Lightweight, flexible materials such as steel and wood can allow the building to bend or sway without collapsing. Engineers are also beginning to incorporate innovative new materials like bamboo and memory alloy (a flexible material that returns to its shape easily) into structures.

Shape

Earthquake-resistant buildings are often designed to have a wide base which will keep the structure stable and less likely to topple over. Buildings which have a symmetrical or pyramid shape are also much less likely to collapse.

Dampeners

Primarily used in skyscrapers, this method involves fixing a large weight at the top of the structure. When the building begins to sway, the weight acts like a pendulum and moves in the opposite direction to stabilize the building.

DID YOU KNOW?

The epicentre of an earthquake is the area on the surface, above the point where the earthquake originated. Measuring the speed of seismic waves enables scientists to locate the epicentre of an earthquake.

QUIZ

5-10m

What kind of mechanism changes rotary to linear motion?

....

....

Where do 80% of the world's earthquakes occur?

....

....

What is the epicentre of an earthquake?

....

....

Why is the inner core of the earth solid, despite being incredibly hot?

....

....

In which layer of the earth is magma found?

....

....

QUIZ

What force is generated when tectonic plates push and grind together?

....

....

How does the energy from an earthquake travel through the earth?

....

....

Which type of construction reinforcement can stop buildings from twisting?

....

....

What type of base provides more stability to a building?

....

....

How do shock absorbers protect buildings from damage caused by earthquakes?

....

....

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