
Pressure

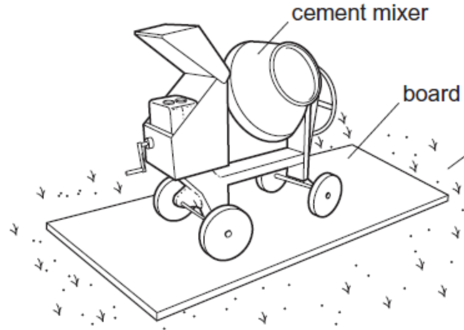
Definition: Pressure is defined as force per unit area

Formula: $P=\frac{F}{A}$

Units: N/m^2 or Pascal.

12 To prevent a cement mixer sinking into soft ground, the mixer is placed on a large flat board.

0625/11/M/J/10



Why does this prevent the mixer sinking?

A The large area decreases the pressure on the ground.

B The large area increases the pressure on the ground.

C The large area decreases the weight on the ground.

D The large area increases the weight on the ground.

Here, the large area decreases the pressure on the ground. This is because the mass of the mixer does not change and hence nor does its weight. Ans: A

Pressure exerted by solids can be found using the formula :$P=\frac{F}{A}$

Numerical:

(c) The area of the piston is $5.5 \times 10^{-3} m^2$ ($0.0055 m^2$). M/J/15-P32-Q2

Calculate the force exerted by the gas on the piston when the pressure is 800 kPa.

SOLUTION:

Pressure=$\frac{F}{A}$

It is important to convert 800kPa to 800 000Pa .Then substitute in the formula $\Rightarrow$ F=$P \times A = 800000 \times 0.0055$ ==4400N

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6 (a) A man squeezes a pin between his thumb and finger, as shown in Fig. 6.1.

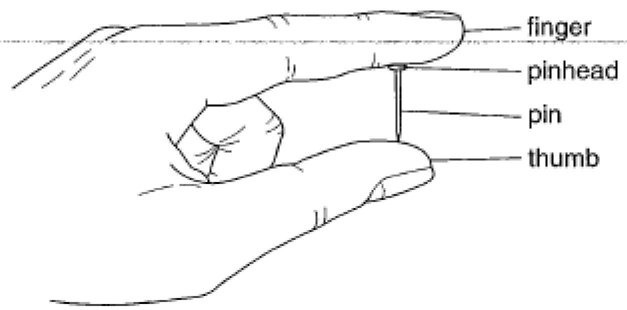


Fig. 6.1

The finger exerts a force of 84 N on the pinhead.

The pinhead has an area of $6.0 \times 10^{-5}\,m^2$.

(i) Calculate the pressure exerted by the finger on the pinhead.

P=F/A

$= 84/6 X 10^{-5}$

$= 1.4 X 10^6$

(ii) State the value of the force exerted by the pin on the thumb.

84n

(b) The density of the water in a swimming pool is $1000\,kg/m^3$. The pool is 3 m deep.

(i) Calculate the pressure of the water at the bottom of the pool.

P= hpg

$= 3 x 1000 x 10$

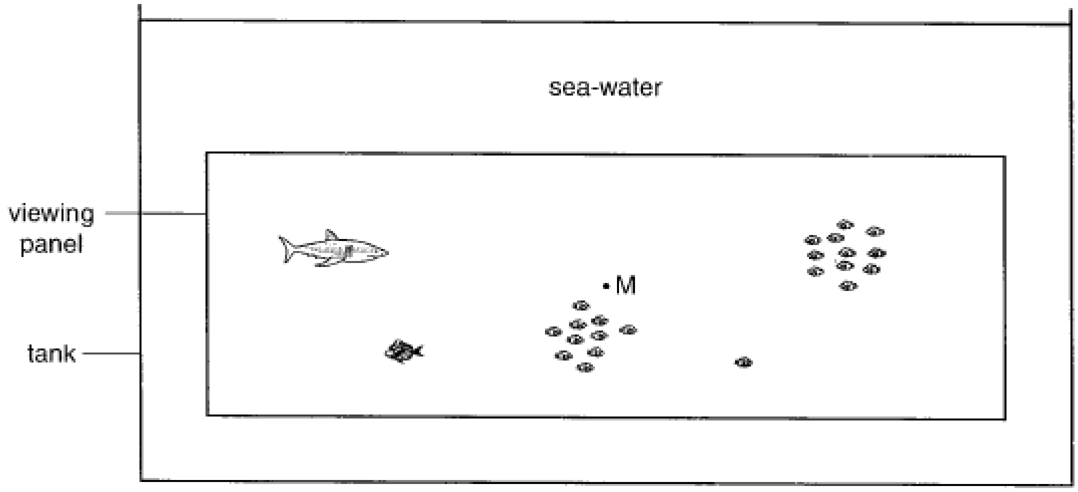
$3 x 10^4$

(ii) Another pool has the same depth of water but has twice the area.

State the pressure of the water at the bottom of this pool.

$3 x 10^4$

1 Fig. 1.1 shows a side view of a large tank in a marine visitor attraction.



The tank is 51 m long and 20 m wide. The sea-water in the tank is 11 m deep and has a density of 1030 kg / m^3.

(a) Calculate the mass of water in the tank.

d=m/v
m= d x v
= 1030 x 51 × 20 × 11
= 11 556 600
=1.2 × 107 kg

(b) The pressure at point M, halfway down the large viewing panel, is 60 kPa more than atmospheric pressure.

Calculate the depth of M below the surface of the water.

$p = \rho g(\Delta)h$
$\Delta h = 60\,000 / (1030 \times 10)$
$= 5.8 m$

(c) The viewing panel is 32.8 m wide and 8.3 m high.

Calculate the outward force of the water on the panel. Assume that the pressure at M is the average pressure on the whole panel.

use of F = pA
= 60 000 × 32.8 × 8.3
= 60 000 × 272.2
$=1.6 \times 10^7$ *N*

Application based questions:

10 A man stands on the ground.

0625/13/M/J/13

Which action will increase the pressure that the man exerts on the ground?

A The man slowly bends his knees.

B The man slowly lies down on the ground.

C The man slowly raises his arms.

D The man slowly raises one foot off the ground.

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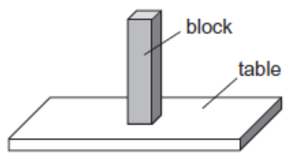
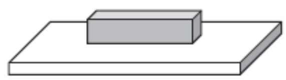
11 A block with flat, rectangular sides rests on a table.

0625/11/M/J/15



The block is now turned so that it rests with its largest side on the table.



How has this change affected the force and the pressure exerted by the block on the table?

	force	pressure
A	decreased	decreased
B	decreased	unchanged
C	unchanged	decreased
D	unchanged	unchanged

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11 The diagram shows a solid block resting on a bench. The dimensions of the block are shown.

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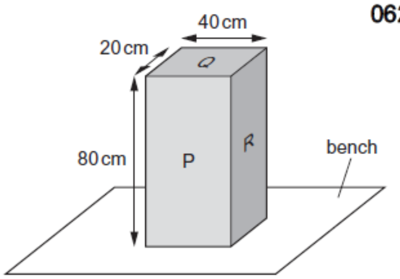

On which labelled surface should the block rest to produce the smallest pressure on the bench?

A P

B Q

C R

D any of P, Q or R

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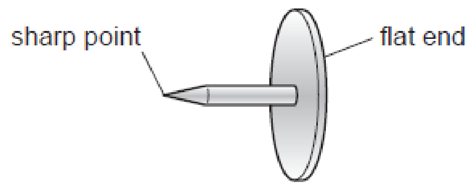
11 A drawing pin (thumb tack) has a sharp point and a flat end. **0625/12/O/N/13**



The pin is pushed into a wooden board.

How do the pressure and the force at the sharp point compare with the pressure and the force at the flat end?

	force at the sharp point	pressure at the sharp point
A	greater than at the flat end	greater than at the flat end
B	greater than at the flat end	less than at the flat end
C	the same as at the flat end	greater than at the flat end
D	the same as at the flat end	less than at the flat end

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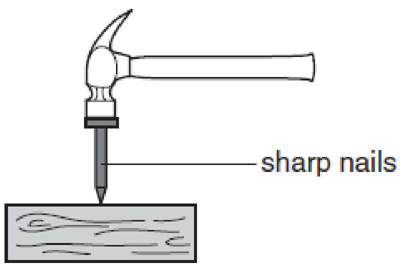
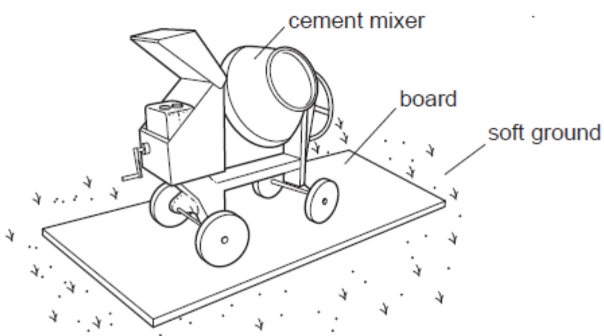
Real life applications of solid pressure:

- Hammering objects using a nail with the sharp tip.



- Placing cement mixers on flat boards in case they tend to sink



- By using sharp knives to cut objects with ease: A sharp knife has a much smaller are in contact with the object being cut . So the force applied acts on a very small area and cuts the object with ease.

DISADVANTAGES OF PRESSURE:

People confined to bed suffer from bed sores. The entire weight of the person falls on the small area of the skin. The skin is not strong enough to bear this weight and the skin is rubbed away causing bed sores.

Pressure exerted by fluids:

Properties of pressure exerted by fluids are:

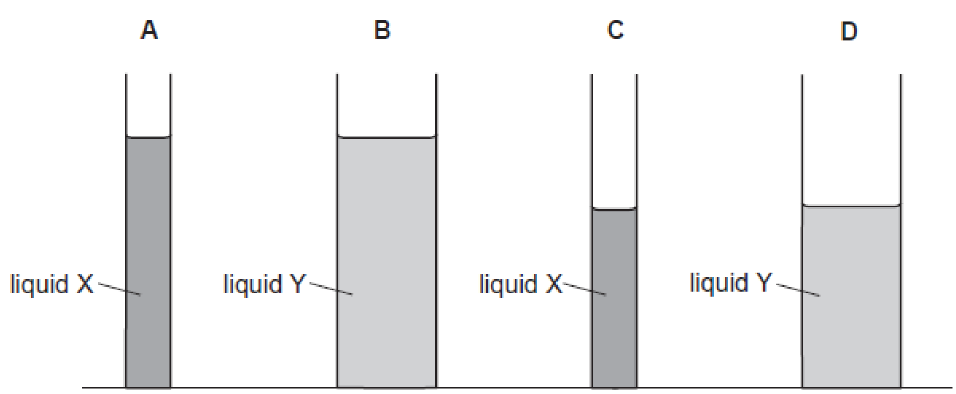
- Pressure of a liquid increases with depth
- The pressure in a liquid depends on the density of the liquid.
- Pressure of a liquid acting alone the same horizontal line is the same.

Example:

2 Liquid X has a density of 1010 kg / m^3. Liquid Y has a density of 950 kg / m^3.

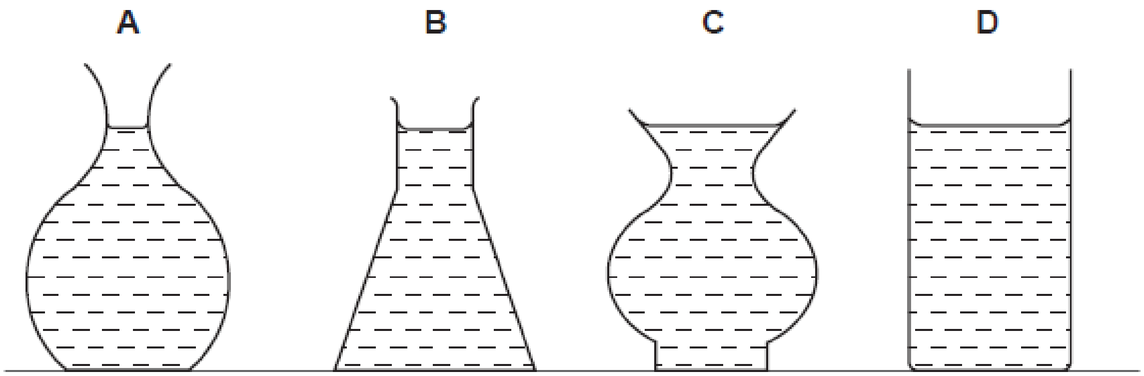
The liquids are poured into tubes as shown. 0625/13/O/N/10

Which tube has the greatest pressure on its base?



Here , the greatest pressure can be exerted either by diagrams shown in A or B. Since the density of Liquid X is greater than the density of liquid Y, hence liquid X in figure A exerts the greatest pressure.

In this diagram , assuming that the mass of liquid is the same in all the 4 containers, and all the four containers have the liquid at the same level, then



the pressure exerted by the liquid column is the same for each container. But container C will exert the maximum pressure on the table as the surface area in contact with the table is the least so the entire mass falls on a small surface area so exerts the greatest pressure.

Application based questions:

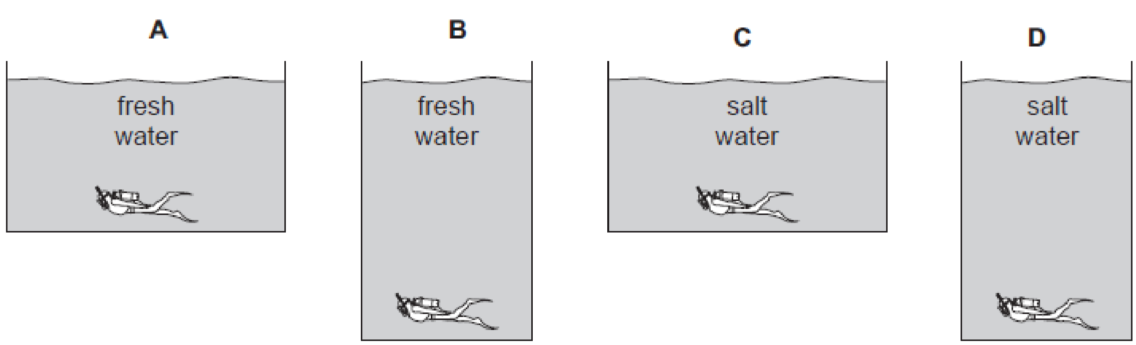
MCQ:

12 The diagrams show four divers at the bottom of four different swimming pools.

Two swimming pools contain fresh water and two contain salt water. Fresh water is less dense than salt water.

0625/12/O/N/13

Which diver feels the least pressure from the water?



9 The diagram shows three different containers J, K and L. Each container contains water of the same depth.

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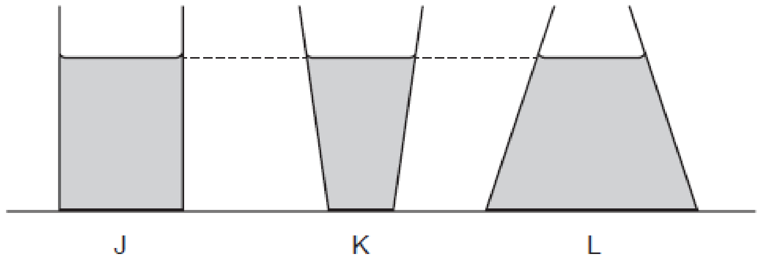

Which statement about the pressure of the water on the base of each container is correct?

A The water pressure is greatest in container J.

B The water pressure is greatest in container K.

C The water pressure is greatest in container L.

D The water pressure is the same for all three containers.

12 Liquid X has a density of 1010 kg / m^3. Liquid Y has a density of 950 kg / m^3.

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0625/12/O/N/10

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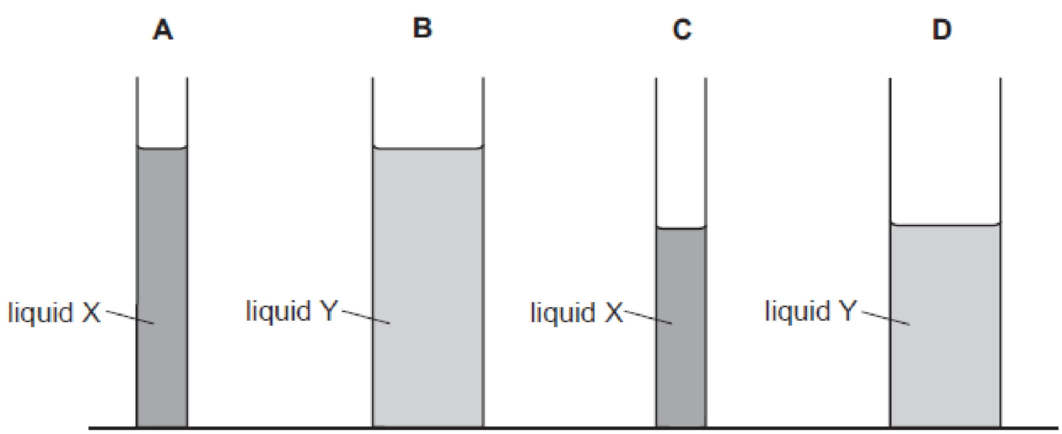

Pressure exerted by a liquid column can be found out by using the formula:

Pressure $(P) = h\rho g$

where h= height of the liquid column

ρ= density of the liquid

g= acceleration due to gravity

NUMERICAL:

2 Fig. 2.1 shows a reservoir that stores water. 76

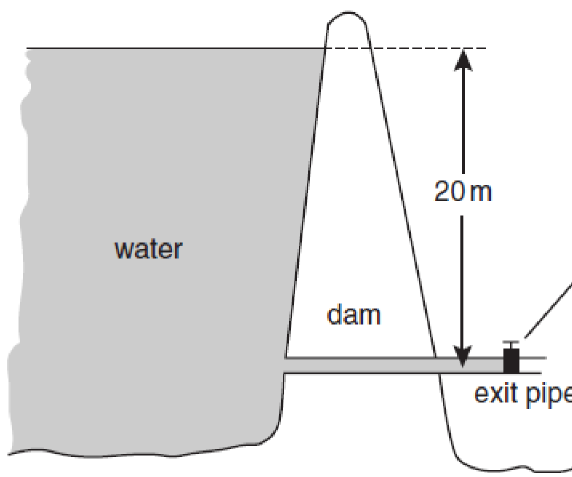

Fig. 2.1

(a) The valve in the exit pipe is closed. The density of water is 1000 kg/m^3 and the acceleration of free fall is 10 m/s^2.
Calculate the pressure of the water acting on the closed valve in the exit pipe.

Pressure=$h\rho g$ = 20 x 1000 x 10= 2 x 10^5Pa

(b) The cross-sectional area of the pipe is 0.5 m^2.
Calculate the force exerted by the water on the closed valve.

Force= Pressure X Area

= 2 x 10^5 x 0.5= 1 x10^5 N

4 An archaeologist is investigating a shipwreck and discovers a wooden box on the seabed.

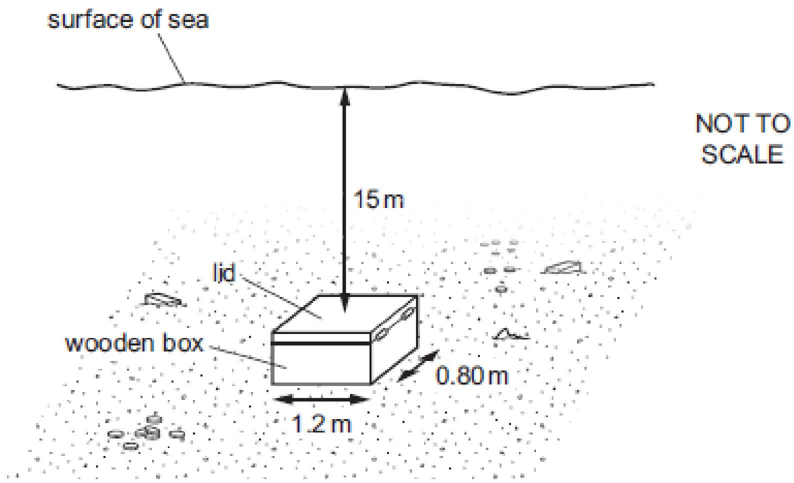

Fig. 4.1

The dimensions of the lid of the box are 1.2 m by 0.80 m and the pressure of the atmosphere is 1.0×10^5 Pa. The lid is 15 m below the surface of the sea.

(a) The density of sea-water is 1020 kg / m^3.

Calculate

(i) the pressure on the lid of the box due to the sea-water,

$P = h\rho g$

$= 15 \times 1020 \times 10$

$= 150\ 000$ Pa / 150 kPa

pressure = 150kPa .... [2]

(ii) the total pressure on the lid,

pressure due to sea water + atmospheric pressure

pressure = 250kPa .... [1]

(iii) the downward force that the total pressure produces on the lid.

P = F / A

Force =(253 000 × 1.2 × 0.8 =)

240 000 N

force = 240 000N [2]

(b) The force needed to open the lid is **not** equal to the value calculated in **(a)(iii)**.

Suggest two reasons for this.

1. Drag of water

2. Friction of the hinge [2]

(a) The pond is kept at a depth of 2.0 m. The density of water is 1000 kg/m^3.

Calculate the water pressure on the valve. O/N/2005-P3=Q3

pressure =…………………….. [2]

(b) The force required to open the valve is 50 N. The valve will open when the water depth reaches 2.0 m.

Calculate the area of the valve.

area = ……………………….. [2]

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2 Fig. 2.1 shows a diver 50 m below the surface of the water.

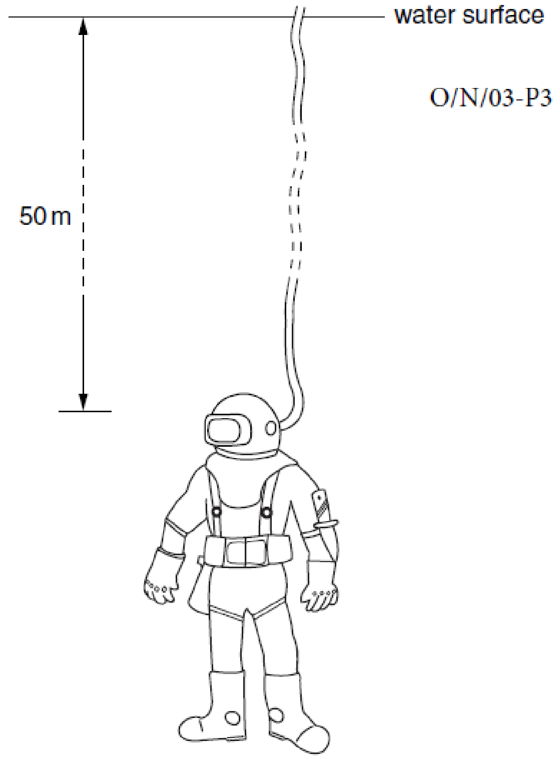

Fig. 2.1

(a) The density of water is 1000 kg/m^3 and the acceleration of free fall is 10 m/s^2. Calculate the pressure that the water exerts on the diver.

pressure = ... [3]

(b) The window in the diver's helmet is 150 mm wide and 70 mm from top to bottom.

Calculate the force that the water exerts on this window.

force = ... [3]

APPLICATIONS OF FLUID PRESSURE:

Vehicles are stopped due to the friction between the road and the tyres. This occurs when forces are applied to stop the rotating wheels. These forces originate when the driver puts the foot on the brake pedal.

The force provided by the foot acts on a piston in a master cylinder to push the brake fluid (oil) along very strong flexible tubes all the way to the braking mechanisms close to the wheels. Figure shows the connection to only one of the wheels. In the braking mechanisms at each wheel the fluid pressure acts on pistons to force the brake pads onto a metal disc on the wheel, creating fiction which slows its rotational speed. Because the total area of all the brake cylinders is much larger than the area of the master cylinder, the magnitude of the force is greatly increased.
