PHYSICS 0625 · CHAPTER 1

Motion, Forces and Energy

Measuring length, volume and time, scalars and vectors, speed, velocity and acceleration and their graphs, mass, weight and density, Newton's laws, friction and terminal velocity, springs, circular motion, moments and stability, momentum, energy, work, energy resources, efficiency, power and pressure.

NOTE

Where a calculation needs the gravitational field strength g, the syllabus value is about $9.8\ \text{N/kg}$. Exam questions say which value to use, and many use $10\ \text{N/kg}$. The worked examples in these notes use $g = 10\ \text{N/kg}$ and say so.

1.1 Physical quantities and measurement techniques

Units and prefixes

Every physical quantity is a number and a unit. The SI units you need first are the metre (m) for length, the kilogram (kg) for mass, the second (s) for time and the kelvin (K) for temperature.

Prefix	Symbol	Meaning
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Measuring length

- A **ruler** or **tape** measures lengths from about a millimetre up. Put your eye directly above the mark, so the reading is not shifted by looking from the side (this error is called parallax).
- A **micrometer** measures very small lengths, such as the thickness of a wire, to $0.01\ \text{mm}$.

Note Academy

Reading a micrometer. Add the reading on the main (sleeve) scale to the reading on the rotating thimble.

- The sleeve scale shows whole millimetres and half millimetres.
- The thimble has 50 divisions, and one full turn moves the spindle $0.5\ \text{mm}$, so each thimble division is $0.01\ \text{mm}$.

> **TRY IT**
>
> A micrometer shows $5.5\ \text{mm}$ on the sleeve and 28 on the thimble. What is the diameter of the wire?

$5.5 + 28 \times 0.01 = 5.78\ \text{mm}$

> **NOTE**
>
> Close the micrometer with nothing in it first. If it does not read zero, that is a **zero error**. Subtract it from every reading (add it if it is negative).

Measuring volume

- A **measuring cylinder** measures the volume of a liquid. Stand it on a level surface and read the scale at the bottom of the curved surface of the liquid (the meniscus), with your eye level with it.
- To find the volume of an **irregular solid** by displacement, record the water level, lower the solid in gently, and record the new level. The volume of the solid is the difference.

> **TRY IT**
>
> A stone raises the water level in a measuring cylinder from $40\ \text{cm}^3$ to $65\ \text{cm}^3$. What is its volume?

$65 - 40 = 25\ \text{cm}^3$

Measuring time

Use a clock or a stopwatch (digital timers read to $0.01\ \text{s}$). A person's reaction time when starting and stopping a stopwatch is about $0.2\ \text{s}$, so for a short interval the error is large compared with the time being measured.

Averaging to measure small quantities

To measure something small, measure many of them together and divide.

Note Academy

- **A short time.** To find the period of a pendulum (the time for one complete swing to and fro), time 20 oscillations and divide by 20. This spreads the reaction-time error over all 20.
- **A small distance.** To find the thickness of one sheet of paper, measure a stack of 100 sheets and divide by 100.

> TRY IT
>
> A pendulum makes 20 complete oscillations in $32.0\ \text{s}$. What is its period?

$\frac{32.0}{20} = 1.60\ \text{s}$

Scalars and vectors

- A **scalar** has magnitude (size) only.
- A **vector** has magnitude **and** direction.

Scalars	Vectors
distance, speed, time, mass, energy, temperature	displacement, velocity, acceleration, force, weight, momentum, electric field strength, gravitational field strength

The resultant of two vectors at right angles. The resultant is the single vector that has the same effect as the two together. For vectors at right angles, draw them as the two short sides of a right-angled triangle. The resultant is the hypotenuse, and you can find its size with Pythagoras' theorem. You can also draw it to scale and measure it.

> TRY IT
>
> A boat is pushed $3\ \text{N}$ east by the engine and $4\ \text{N}$ north by the current. Find the size of the resultant force.

$\sqrt{3^2 + 4^2} = \sqrt{25} = 5\ \text{N}$

Its direction makes an angle $\tan^{-1}\left(\frac{4}{3}\right) = 53°$ with the $3\ \text{N}$ force.

1.2 Motion

Speed, velocity and acceleration

$$\text{speed} = \frac{\text{distance}}{\text{time}}\text{, that is } v = \frac{s}{t}. \qquad \text{average speed} = \frac{\text{total distance}}{\text{total time}}.$$

Note Academy

- **Speed** is the distance travelled per unit time. It is a scalar.
- **Velocity** is the change in displacement per unit time. It is a vector, so it has a direction.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}, \text{ that is } a = \frac{\Delta v}{\Delta t}.$$

Acceleration is measured in m/s^2. A **deceleration** is a negative acceleration.

- **Uniform acceleration** means the velocity changes by the same amount every second (for example, an object in free fall).
- **Non-uniform acceleration** means the acceleration itself is changing (for example, a car pulling away from the lights while the driver keeps changing gear).

TRY IT

A car speeds up from $5\ \text{m/s}$ to $25\ \text{m/s}$ in $8\ \text{s}$. Find its acceleration.

$a = \frac{25-5}{8} = 2.5\ \text{m/s}^2$

TRY IT

A train slows from $20\ \text{m/s}$ to rest in $5\ \text{s}$. Find its acceleration.

$a = \frac{0-20}{5} = -4\ \text{m/s}^2$

The negative sign shows deceleration.

Distance–time graphs

The **gradient** of a distance–time graph is the speed.

Shape of the line	What the object is doing
horizontal	at rest
straight, sloping up	constant speed (the steeper the line, the faster)
curving upwards, getting steeper	accelerating
curving, getting flatter	decelerating

Note Academy

Speed–time graphs

The **gradient** of a speed–time graph is the acceleration. The **area under the graph** is the distance travelled.

Shape of the line	What the object is doing
horizontal, on the time axis	at rest
horizontal, above the time axis	constant speed
straight, sloping up	constant acceleration
straight, sloping down	constant deceleration
curved	changing acceleration

> **TRY IT**
>
> A speed–time graph for a cyclist is a straight line from 0 to 20 m/s in the first 10 s, a horizontal line at 20 m/s from 10 s to 30 s, then a straight line down to 0 at 40 s. Find the acceleration in each part, the total distance, and the average speed.

- First 10 s: $a = \dfrac{20 - 0}{10} = 2$ m/s^2.
- Next 20 s: constant speed, so $a = 0$.
- Last 10 s: $a = \dfrac{0 - 20}{10} = -2$ m/s^2.

Distance is the area under the graph, split into a triangle, a rectangle and a triangle:

$$\tfrac{1}{2} \times 10 \times 20 + 20 \times 20 + \tfrac{1}{2} \times 10 \times 20 = 100 + 400 + 100 = 600 \text{ m}$$

$$\text{average speed} = \tfrac{600}{40} = 15 \text{ m/s}$$

Free fall

Near the Earth's surface, an object falling with no air resistance has a constant acceleration of free fall, $g \approx 9.8$ m/s^2. In air, drag (air resistance) reduces the acceleration. In a vacuum, a feather and a coin fall together.

> **TRY IT**
>
> A stone is dropped from rest. Use $g = 10$ m/s^2 and ignore air resistance. How fast is it moving after 3 s?

Note Academy

$\Delta v = a\,\Delta t = 10 \times 3 = 30$ m/s

1.3 Mass and weight

- **Mass** is a measure of the quantity of matter in an object. It is measured in kilograms. It is a scalar and does not change from place to place.
- **Inertia** is the resistance of an object to a change in its state of rest or motion. The bigger the mass, the bigger the inertia.
- **Weight** is the gravitational force on an object. It is a vector (it points towards the centre of the Earth) and is measured in newtons.

A **gravitational field** is a region in which a mass experiences a force because of gravitational attraction.

> gravitational field strength $= \dfrac{\text{weight}}{\text{mass}}$, **that is** $g = \dfrac{W}{m}$, **so** $W = mg$. **Its unit is** N/kg, **and it is the same as the acceleration of free fall in** m/s^2.

Place	g (N/kg)
Earth	about 9.8 (often taken as 10)
Moon	about 1.6

Measuring. A **beam balance** or equal-arm balance compares weights, so it also compares masses (because g is the same for both pans). An **electronic balance** reads mass directly. A **force meter** (newton meter) measures weight.

> TRY IT
>
> An astronaut has a mass of 60 kg. Find her weight on the Earth (use $g = 10$ N/kg) and on the Moon ($g = 1.6$ N/kg). What is her mass on the Moon?

- On the Earth: $W = 60 \times 10 = 600$ N.
- On the Moon: $W = 60 \times 1.6 = 96$ N.
- Her mass is still 60 kg. Mass does not change.

1.4 Density

> density $= \dfrac{\text{mass}}{\text{volume}}$, **that is** $\rho = \dfrac{m}{V}$.

Note Academy

Density is measured in kg/m^3 or g/cm^3. Water has a density of $1.0\ \text{g/cm}^3$, which is $1000\ \text{kg/m}^3$. To change g/cm^3 into kg/m^3, multiply by 1000.

An object whose density is less than the liquid's density floats in it.

Finding the density of

- **a liquid.** Find the mass of an empty measuring cylinder. Pour in some liquid and read its volume. Find the mass of the cylinder with the liquid. The mass of the liquid is the difference. Divide by the volume.
- **a regularly shaped solid.** Measure its mass with a balance. Measure its dimensions with a ruler and calculate the volume (for a cuboid, length × width × height). Divide.
- **an irregular solid that sinks.** Measure its mass. Find its volume by displacement in a measuring cylinder. Divide.

TRY IT

A block measures $8\ \text{cm}$ by $5\ \text{cm}$ by $2\ \text{cm}$ and has a mass of $240\ \text{g}$. Find its density.

$V = 8 \times 5 \times 2 = 80\ \text{cm}^3 \qquad \rho = \frac{240}{80} = 3.0\ \text{g/cm}^3$

TRY IT

A stone of mass $54\ \text{g}$ raises the water level from $40\ \text{cm}^3$ to $60\ \text{cm}^3$. Find its density.

$V = 60 - 40 = 20\ \text{cm}^3 \qquad \rho = \frac{54}{20} = 2.7\ \text{g/cm}^3$

Note Academy

1.5.1 Balanced and unbalanced forces

Types of force

Force	What it is
weight (gravitational force)	the pull of a planet on a mass
friction	a force between surfaces that opposes sliding
drag, air resistance	friction in a fluid (a liquid or a gas)
tension (elastic force)	a pull in a stretched string, rope or spring
electrostatic force	the force between electric charges
magnetic force	the force between magnets, or on magnetic materials
thrust (driving force)	the push that makes something go forward
contact force	the push of one surface on another (it acts at right angles to the surface)

A **free-body diagram** shows one object on its own, with an arrow for each force acting **on** it. The length of an arrow shows the size of the force, and its direction shows the direction of the force. For a book resting on a table there are two arrows: weight down and the contact force from the table up, of equal length.

Newton's first law

> **An object either remains at rest or continues to move in a straight line at constant speed unless it is acted on by a resultant force.**

A force can change the velocity of an object by changing its speed or its direction of motion, or both.

Resultant force

For forces along the same straight line, add forces in the same direction and subtract forces in opposite directions. If the resultant force is zero, the forces are **balanced**: the object is at rest or moving at constant velocity.

Note Academy

Newton's second law

> resultant force = mass × acceleration, **that is** $F = ma$**.**

The force is in newtons (N), the mass in kilograms and the acceleration in $\mathrm{m/s^2}$.

> TRY IT
>
> A car of mass $1200\ \mathrm{kg}$ is driven forward by an engine force of $3000\ \mathrm{N}$ against a total resistance of $600\ \mathrm{N}$. Find its acceleration.

$F = 3000 - 600 = 2400\ \mathrm{N} \qquad a = \frac{2400}{1200} = 2.0\ \mathrm{m/s^2}$

Newton's third law

> **When object A exerts a force on object B, object B exerts an equal and opposite force on object A.**

The two forces of a pair are always **the same type of force** and act on **different objects**.

> NOTE
>
> A book on a table: the weight of the book (the Earth pulling the book down) is **not** the third-law pair of the contact force from the table. Its pair is the book pulling the Earth up. The pair of the contact force on the book is the force of the book pushing down on the table.

1.5.2 Friction

- Friction is a force that opposes motion between two surfaces in contact. It can also produce **heating** (rub your hands together).
- Drag is friction in a liquid or a gas. It increases with speed.

Terminal velocity

When a skydiver jumps, the only force at first is weight, so the acceleration is g. As the speed rises, so does the air resistance.

1. Weight is constant and drag grows as speed grows.
2. The resultant force (weight minus drag) gets smaller, so the acceleration gets smaller.

Note Academy

3. When drag equals weight, the resultant force is zero and the acceleration is zero.
4. The skydiver now falls at a constant speed. This is the **terminal velocity**.

When the parachute opens, the drag suddenly becomes bigger than the weight. The skydiver decelerates until drag again equals weight, at a much smaller terminal velocity.

Stopping distance of a vehicle

$$\text{stopping distance} = \text{thinking distance} + \text{braking distance}$$

- **Thinking distance** is the distance travelled between the driver seeing a hazard and pressing the brake.
- **Braking distance** is the distance travelled while the brakes slow the vehicle down.

Factor	Effect
higher speed	both distances increase
tiredness, alcohol, drugs	reaction time is longer, so the thinking distance increases
heavier load	braking distance increases
worn tyres, wet or icy road	less friction, so the braking distance increases

1.5.3 Elastic deformation

Forces can change the size and the shape of an object. When a spring is stretched by a load, its **extension** is its new length minus its original length.

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}, \text{ that is } k = \frac{F}{x}. \text{ The unit is N/m.}$$

TRY IT

A force of $4.0\ \text{N}$ stretches a spring by $5.0\ \text{cm}$. Find the spring constant in N/m.

$x = 0.050\ \text{m} \qquad k = \frac{4.0}{0.050} = 80\ \text{N/m}$

Load–extension graphs

Experiment. Hang a spring from a clamp next to a ruler. Add loads of $1\ \text{N}$ at a time and measure the length each time. Subtract the original length to get the extension, and plot extension against load.

Note Academy

- At first the graph is a straight line through the origin. The extension is **directly proportional** to the load (doubling the load doubles the extension).
- The **limit of proportionality** is the point where the line starts to curve. Beyond it the spring stretches by more than it should for each extra newton.

1.5.4 Circular motion

An object moves in a circle only when a force acts at right angles to its motion, pointing towards the centre. This force changes the direction of the velocity all the time, but not the speed. Examples are the tension in a string whirling a ball, friction on the tyres of a car going round a bend, and gravity on a satellite.

For an object moving in a circle:

- if the force increases (with the mass and the radius the same), the **speed increases**;
- if the force increases (with the mass and the speed the same), the **radius decreases**;
- a bigger mass needs a bigger force to keep the same speed and radius.

If the force stops (for example, the string breaks), the object carries on in a straight line in the direction it was moving at that moment.

1.5.5 Turning effect of forces

The **moment** of a force is its turning effect about a point called the pivot.

> moment = force × perpendicular distance from the pivot. **The unit is** N m.

Everyday examples: opening a door (push far from the hinges), using a spanner, a see-saw.

> **Principle of moments. For an object in equilibrium, the sum of the clockwise moments about any point equals the sum of the anticlockwise moments about the same point.**

> TRY IT
>
> A child of weight $300\ \text{N}$ sits $2.0\ \text{m}$ from the pivot of a see-saw. Where must a child of weight $400\ \text{N}$ sit on the other side to balance it?

$$300 \times 2.0 = 400 \times d \quad \Rightarrow \quad d = \frac{600}{400} = 1.5\ \text{m}$$

Verifying the principle. Balance a metre rule on a pivot at its centre. Hang a weight on each side and move them until the rule is horizontal. Measure each distance from the pivot, calculate the two moments, and show that they are equal.

Note Academy

1.5.6 Centre of gravity

The **centre of gravity** of an object is the point where the whole weight of the object appears to act.

Finding the centre of gravity of a flat shape (a lamina) with a plumb line.

1. Make a small hole near the edge of the shape and hang it from a pin so it can swing freely.
2. Hang a plumb line (a string with a weight) from the same pin. When it stops, draw a line on the shape along the string.
3. Repeat from two other holes.
4. The lines cross at the centre of gravity.

Stability. An object is more stable if it has a **low** centre of gravity and a **wide** base. If the line of the weight, drawn down from the centre of gravity, falls outside the base when the object is tilted, it topples over. This is why a double-decker bus is tested by tilting it, and why racing cars are low and wide.

1.6 Momentum

NOTE

Supplement only. This topic is in the Extended (Supplement) syllabus, so it is asked in Papers 2, 4 and 6. If you sit the Core papers you do not need it.

momentum $=$ mass $\times$ velocity**, that is** $p = mv$**. The unit is** kg m/s**. Momentum is a vector.**

impulse $= F\,\Delta t = \Delta(mv)$**. A resultant force is the rate of change of momentum:** $F = \dfrac{\Delta p}{\Delta t}$**.**

Conservation of momentum. When objects interact and no external force acts, the total momentum before equals the total momentum after.

TRY IT

A $1000\ \text{kg}$ truck moving at $6.0\ \text{m/s}$ hits a stationary $500\ \text{kg}$ car, and they move off together. Find their speed.

$$1000 \times 6.0 + 500 \times 0 = (1000 + 500)\,v \quad \Rightarrow \quad v = \frac{6000}{1500} = 4.0\ \text{m/s}$$

TRY IT

Note Academy

A footballer kicks a stationary $0.40\ \text{kg}$ ball and it leaves the foot at $20\ \text{m/s}$. The foot is in contact with the ball for $0.020\ \text{s}$. Find the average force.

$F = \frac{\Delta p}{\Delta t} = \frac{0.40 \times 20 - 0}{0.020} = 400\ \text{N}$

1.7.1 Energy

Energy is stored in different ways:

- **kinetic** (moving objects)
- **gravitational potential** (objects raised in a gravitational field)
- **chemical** (fuels, food, batteries)
- **elastic (strain)** (stretched or squashed springs)
- **nuclear** (the nucleus of an atom)
- **electrostatic** (between charges)
- **internal (thermal)** (the random motion of particles)

Energy is transferred between stores by **forces** (mechanical work done), **electrical currents** (electrical work done), **heating**, and by **waves** (light, sound and other waves).

Conservation of energy. Energy cannot be created or destroyed. It can only be transferred from one store to another, or from one place to another. The total energy stays the same.

kinetic energy $E_k = \frac{1}{2}mv^2$. change in gravitational potential energy $\Delta E_p = mg\,\Delta h$.

The unit of energy is the joule (J).

TRY IT

Find the kinetic energy of a $2.0\ \text{kg}$ trolley moving at $3.0\ \text{m/s}$.

$E_k = \frac{1}{2} \times 2.0 \times 3.0^2 = 9.0\ \text{J}$

TRY IT

A $5.0\ \text{kg}$ box is lifted $2.0\ \text{m}$. Find the gain in gravitational potential energy (use $g = 10\ \text{N/kg}$).

$\Delta E_p = 5.0 \times 10 \times 2.0 = 100\ \text{J}$

Note Academy

TRY IT

A ball is dropped from a height of $20\ \text{m}$. Ignoring air resistance, with $g = 10\ \text{N/kg}$, find its speed just before it hits the ground.

The loss of potential energy equals the gain of kinetic energy:

$$mgh = \tfrac{1}{2}mv^2 \quad \Rightarrow \quad v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = \sqrt{400} = 20\ \text{m/s}$$

The mass cancels, so the answer does not depend on it.

1.7.2 Work

work done = force × distance moved in the direction of the force**, that is $W = Fd$. The unit is the joule: $1\ \text{J} = 1\ \text{N m}$.**

Work done is the energy transferred by a force.

TRY IT

A worker pushes a crate with a force of $50\ \text{N}$ and moves it $4.0\ \text{m}$ in the direction of the force. How much work is done?

$$W = 50 \times 4.0 = 200\ \text{J}$$

1.7.3 Energy resources

- **Non-renewable** resources will run out: fossil fuels (coal, oil, natural gas) and nuclear fuel.
- **Renewable** resources are replaced as fast as they are used: biofuels, hydroelectric, solar, geothermal, wind, tides and waves.

In most power stations a fuel heats water in a **boiler** to make steam. The steam turns a **turbine**, which turns a **generator** that produces electricity.

Note Academy

Source	How useful energy is obtained	Advantages	Disadvantages
fossil fuels	burn the fuel in a boiler; the steam drives a turbine and generator	available any time, cheap, reliable	non-renewable; releases carbon dioxide (global warming) and other pollution
biofuels	burn plant material or fuel made from it, in the same way	renewable; carbon dioxide absorbed when the plants grew	needs land that could grow food; still releases carbon dioxide when burned
hydroelectric	falling water turns a turbine and generator	renewable; no pollution when running; can respond quickly	needs a dam and a suitable valley; floods land and damages habitats
solar	solar cells give electricity directly; solar panels heat water	renewable; no pollution when running	works only in daylight and depends on the weather; large area needed
nuclear fuel	fission of uranium heats water to steam for a turbine and generator	no carbon dioxide; a small amount of fuel gives a lot of energy	non-renewable; radioactive waste; risk of accidents
geothermal	hot rocks heat water to steam for a turbine and generator	renewable; reliable	only in a few places; drilling is costly
wind	wind turns a turbine and generator	renewable; no pollution when running	only when the wind blows; noise and visual impact
tides	tide flowing in and out turns turbines in a barrage	renewable; predictable	the barrage damages habitats; only in suitable estuaries
waves	sea waves move floats that drive generators	renewable	depends on the weather; hard to build and maintain in the sea

Note Academy

1.7.4 Efficiency

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\% \quad \text{or} \quad \frac{\text{useful power output}}{\text{total power input}} \times 100\%.$$

No machine is 100% efficient. The rest of the energy is **wasted**, usually as thermal energy in the surroundings.

TRY IT

A motor takes in $500\ \text{J}$ of electrical energy and does $350\ \text{J}$ of useful work. Find its efficiency.

$\frac{350}{500} \times 100\% = 70\%$

TRY IT

A lamp has an input power of $60\ \text{W}$ and gives out $6\ \text{W}$ of light. Find its efficiency.

$\frac{6}{60} \times 100\% = 10\%$

1.7.5 Power

$\text{power} = \frac{\text{work done}}{\text{time taken}}$**, that is** $P = \frac{W}{t}$**. Also** $P = \frac{\Delta E}{t}$ **for energy transferred. The unit is the watt:** $1\ \text{W} = 1\ \text{J/s}$**.** $1\ \text{kW} = 1000\ \text{W}$**.**

TRY IT

A lift raises a $600\ \text{N}$ load through $10\ \text{m}$ in $20\ \text{s}$. Find the power of the lift.

$W = Fd = 600 \times 10 = 6000\ \text{J}$ $P = \frac{6000}{20} = 300\ \text{W}$

1.8 Pressure

$\text{pressure} = \frac{\text{force}}{\text{area}}$**, that is** $p = \frac{F}{A}$**. The unit is the pascal:** $1\ \text{Pa} = 1\ \text{N/m}^2$**.**

The same force gives a bigger pressure on a smaller area. This is why a knife is sharp (small area, large pressure), and why skis and snowshoes are wide (large area, small pressure, so you do not sink).

TRY IT

A box exerts a force of $800\ \text{N}$ on the floor through an area of $0.040\ \text{m}^2$. Find the pressure.

$p = \frac{800}{0.040} = 20\,000\ \text{Pa}$

Pressure on a surface produces a force at right angles to that surface. You can show this with a container with holes in its side: water spurts out at right angles to the surface at each hole.

Note Academy

Atmospheric pressure and the barometer

The air above us has weight, so the atmosphere produces a pressure of about 1.0×10^5 Pa at sea level. A **mercury barometer** is a glass tube sealed at the top, filled with mercury and turned upside down in a dish of mercury. The mercury falls until its column is about 760 mm tall. The pressure of the mercury column at the bottom balances the atmospheric pressure, so the height of the column measures the atmospheric pressure.

Pressure in a liquid

Pressure in a liquid increases with **depth** and with the **density** of the liquid.

change in pressure = density × gravitational field strength × change in height**, that is** $\Delta p = \rho g \, \Delta h$**.**

TRY IT

Find the extra pressure at a depth of 10 m in water of density 1000 kg/m^3 (use $g = 10$ N/kg).

$\Delta p = 1000 \times 10 \times 10 = 1.0 \times 10^5$ Pa

NOTE

The total pressure at that depth is the pressure from the water plus the atmospheric pressure above it. The $\rho g \Delta h$ equation gives only the pressure caused by the liquid.

Note Academy