Force and Motion I

Distance vs displacement

Distance: total path (scalar). Displacement: straight line from start, with direction.

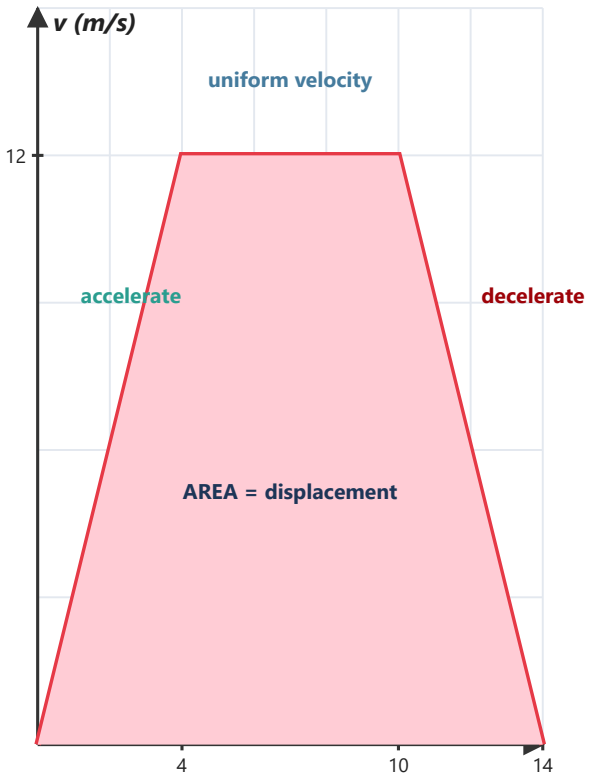
Graphs

s–t gradient = velocity. v–t gradient = acceleration; area = displacement.

Free fall

Only gravity acts: a = g = 9.81 m s^{-2}. All masses fall together in a vacuum.

Velocity–time graph



Inertia

Resists change in motion; bigger mass = bigger inertia. Seat belts!

Momentum

p = mv. Total momentum is conserved in collisions and explosions (no external force).

Impulse

Ft = change in momentum. Longer contact time → smaller force (airbags, crumple zones).

FORMULA / KEY TERMS

- v = u + at · s = ½(u + v)t
- s = ut + ½at^2 · v^2 = u^2 + 2as
- F = ma · p = mv · Ft = mv − mu
- W = mg (weight, N)

COMMON MISTAKE

❌ "A heavier object falls faster."

✅ With no air resistance all objects fall with the SAME acceleration g.

QUICK CHECK (worked answers at the back, page 16)

1. A car speeds up from rest to 20 m s^{-1} in 5 s. Find its acceleration and the distance travelled.
2. A 2 kg trolley at 3 m s^{-1} hits a 1 kg trolley at rest and they stick. Find the common velocity.
3. Explain why a goalkeeper pulls the hands back when catching a ball.

Gravitation

Newton's law

Every two masses attract: $F \propto m_1 m_2$ and $F \propto 1/r^2$.

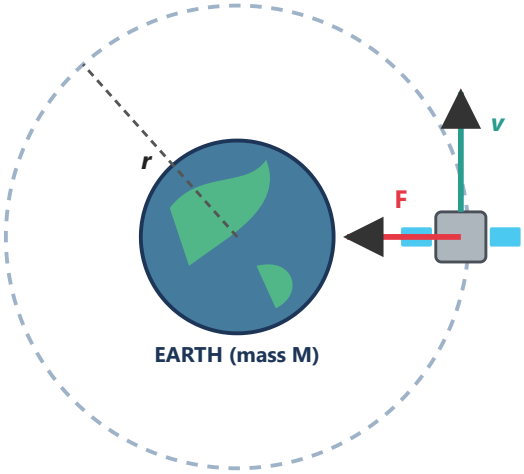
g changes

$g = GM/r^2$: smaller further from Earth; on the Moon about 1/6 of Earth's.

Kepler 1 + 2

Orbits are ellipses with the Sun at one focus; a planet sweeps equal areas in equal times.

Satellite in a circular orbit



Gravity gives the centripetal force:
$GMm/r^2 = mv^2/r \rightarrow v = \sqrt{(GM/r)}$
Higher orbit → slower speed, longer period
Geostationary: period 24 h, above the equator, same direction as Earth spins

Kepler 3

$T^2 \propto r^3$: further planets take much longer to orbit.

Satellites

Geostationary (communication, 24 h); lower orbits for weather and GPS.

Escape velocity

Speed to leave Earth without more push: about 11.2 km s^{-1}.

FORMULA / KEY TERMS

- $F = Gm_1m_2/r^2$ ($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})
- $g = GM/r^2$
- $v = \sqrt{(GM/r)}$ · $v_{escape} = \sqrt{(2GM/r)}$
- $T_1^2/r_1^3 = T_2^2/r_2^3$

COMMON MISTAKE

❌ "r is the height above the ground."

✅ r is measured from the CENTRE of the Earth: r = R(Earth) + height.

QUICK CHECK (worked answers at the back, page 16)

1. The distance between two masses is doubled. What happens to the gravitational force?
2. State the period of a geostationary satellite.
3. Why is the Moon's escape velocity lower than Earth's?

Heat

Thermal equilibrium

Net heat flow is zero when two objects reach the same temperature (how a thermometer works).

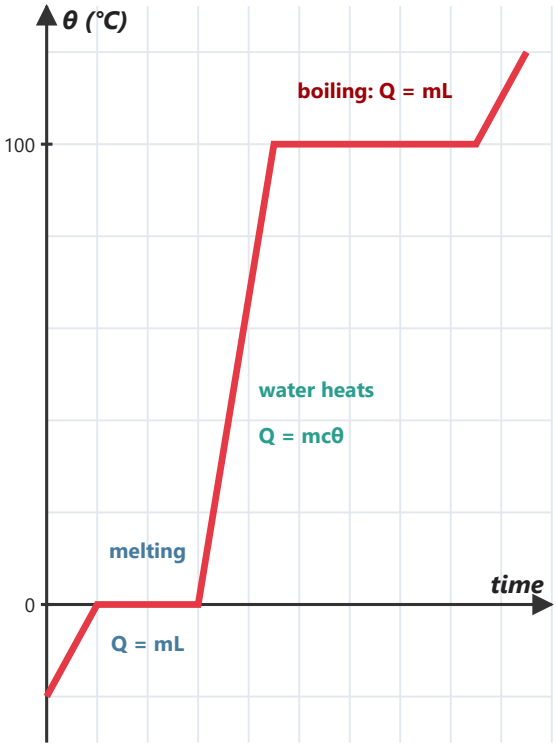
Specific heat capacity

Heat to raise 1 kg by 1 °C. Water is high (4200 J kg^{-1} $°C^{-1}$): good coolant.

Latent heat

Heat to change state with NO temperature change: breaks/forms bonds.

Heating ice to steam



Boyle

Fixed mass, fixed T: $P \propto 1/V$ (PV = constant).

Charles + Gay-Lussac

$V \propto T$ (fixed P); $P \propto T$ (fixed V). T in KELVIN.

Sea breeze

Day: land heats faster (lower c), warm air rises, cool sea air moves in.

FORMULA / KEY TERMS

- $Q = mc\theta$ · $Q = mL$
- $P_1V_1 = P_2V_2$
- $V_1/T_1 = V_2/T_2$ · $P_1/T_1 = P_2/T_2$
- $T(K) = \theta(°C) + 273$

COMMON MISTAKE

❌ "Use °C in the gas laws."

✅ Always change to kelvin first: 27 °C = 300 K.

QUICK CHECK (worked answers at the back, page 16)

1. Find the heat needed to warm 2 kg of water from 25 °C to 75 °C. (c = 4200 J kg^{-1} $°C^{-1}$)
2. A gas at 100 kPa has volume 30 cm^3. It expands to 60 cm^3 at constant temperature. Find the new pressure.
3. Why does sweating cool the body?

Waves

Reflection

Angle of incidence = angle of reflection. λ, f and v unchanged.

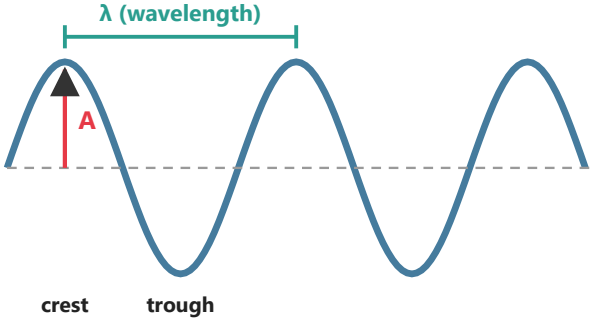
Refraction

Change of speed changes direction. Bends towards the normal when slowing down.

Diffraction

Spreads after a gap/edge. λ, f and v unchanged; amplitude drops.

A transverse wave



Electromagnetic spectrum (long λ → short λ)



Transverse: vibration ⊥ wave direction (light, water)
Longitudinal: vibration ∥ direction (sound)
Into shallow water: speed ↓, λ ↓, f SAME
Diffraction: spreads through a gap, most when gap ≈ λ

Interference

Two coherent sources: constructive (loud/bright) and destructive (quiet/dark).

Sound

Longitudinal; needs a medium. Ultrasound > 20 kHz: scans, sonar.

EM waves

Transverse, travel at 3×10^8 m s^{-1} in vacuum; no medium needed.

📐 FORMULA / KEY TERMS

- $v = f\lambda$ · $f = 1/T$
- Young's double slit: $\lambda = ax/D$
- a = slit separation, x = fringe spacing, D = slit to screen
- Speed of light $c = 3 \times 10^8$ m s^{-1}

⚠️ COMMON MISTAKE

❌ "Frequency changes when a wave enters shallow water."

✅ Frequency is set by the SOURCE and never changes; speed and wavelength change.

✍️ QUICK CHECK (worked answers at the back, page 16)

1. A wave has frequency 50 Hz and wavelength 0.2 m. Find its speed.
2. In a double-slit experiment a = 0.5 mm, D = 2.0 m and x = 2.4 mm. Find λ.
3. What happens to speed, wavelength and frequency when water waves move into shallow water?

Worked Answers (1/2)

Form 4 Chapter 1: Measurement

1. $72 \times 1000 \div 3600 = 20$ m s^{-1}.
2. Displacement: vector. Energy: scalar. Acceleration: vector.
3. $m = (4 - 0) \div (8 - 0) = 0.5$ cm N^{-1}.

Form 4 Chapter 2: Force and Motion I

1. $a = (20 - 0) \div 5 = 4$ m s^{-2}. $s = \frac{1}{2}(0 + 20)(5) = 50$ m.
2. $(2)(3) + (1)(0) = (2 + 1)v \rightarrow v = 6 \div 3 = 2$ m s^{-1}.
3. It increases the time of impact; for the same change in momentum ($Ft = mv - mu$) the force on the hands is smaller.

Form 4 Chapter 3: Gravitation

1. $F \propto 1/r^2$: it becomes ¼ of the original force.
2. 24 hours (same as one rotation of the Earth).
3. $v = \sqrt{(2GM/r)}$; the Moon's mass M is much smaller, so the escape velocity is lower (about 2.4 km s^{-1}).

Form 4 Chapter 4: Heat

1. $Q = 2 \times 4200 \times 50 = 420\,000$ J (420 kJ).
2. $P_2 = P_1V_1 \div V_2 = 100 \times 30 \div 60 = 50$ kPa.
3. Sweat absorbs latent heat of vaporisation from the skin when it evaporates, so the skin loses heat.

Form 4 Chapter 5: Waves

1. $v = 50 \times 0.2 = 10$ m s^{-1}.
2. $\lambda = ax/D = (0.5 \times 10^{-3})(2.4 \times 10^{-3}) \div 2.0 = 6.0 \times 10^{-7}$ m (600 nm).
3. Speed decreases, wavelength decreases, frequency stays the same.

Form 4 Chapter 6: Light and Optics

1. $1/v = 1/10 - 1/30 = 2/30 \rightarrow v = 15$ cm (real). $m = 15 \div 30 = 0.5$ (diminished).
2. $\sin c = 1 \div 1.5 = 0.667 \rightarrow c = 41.8°$.
3. $P = 1 \div 0.25 = +4$ D.

Form 5 Chapter 1: Force and Motion II

1. $R = \sqrt{(3^2 + 4^2)} = 5$ N.
2. $F = 200 \times 0.05 = 10$ N. $E = \frac{1}{2} \times 200 \times 0.05^2 = 0.25$ J.
3. $mg \sin 30° = 10 \times 9.81 \times 0.5 = 49.05$ N.

Key Terms: English – Bahasa Melayu (1/2)

Form 4. Use the English words in your DLP answers; the BM words help when you read BM books or past papers.

English	Bahasa Melayu
physical quantity	kuantiti fizik
base quantity	kuantiti asas
derived quantity	kuantiti terbitan
scalar	skalar
vector	vektor
gradient	kecerunan
displacement	sesaran
velocity	halaju
acceleration	pecutan
deceleration	nyahpecutan
free fall	jatuh bebas
inertia	inersia
momentum	momentum
impulse	impuls
impulsive force	daya impuls
weight	berat
gravitational force	daya graviti
gravitational acceleration	pecutan graviti
orbit	orbit
escape velocity	halaju lepas
satellite	satelit
thermal equilibrium	keseimbangan terma
specific heat capacity	muatan haba tentu
specific latent heat	haba pendam tentu
evaporation	penyejatan
wave	gelombang
transverse	melintang
longitudinal	membujur
amplitude	amplitud
wavelength	panjang gelombang
frequency	frekuensi
period	tempoh
reflection	pantulan
refraction	pembiasan
diffraction	pembelauan
interference	interferens
electromagnetic spectrum	spektrum elektromagnet
refractive index	indeks biasan
critical angle	sudut genting
total internal reflection	pantulan dalam penuh
convex lens	kanta cembung
concave lens	kanta cekung
focal length	panjang fokus
magnification	pembesaran
real image	imej nyata
virtual image	imej maya
apparent depth	dalam ketara

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