



Unit 6 • Force and Motion: motion

Full marks 39

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. motion
2. reference point
3. scalar
4. vector
5. displacement
6. relative velocity
7. acceleration
8. retardation

K • 4

Each carries 0.5 mark.

2 Match the columns

1. relative velocity, bodies moving in the same direction → d. $v_{AB} = v_A - v_B$
2. relative velocity, bodies moving in opposite directions → g. $v_{AB} = v_A + v_B$
3. acceleration → f. $a = (v - u)/t$
4. average velocity, when the velocity changes steadily → b. $(u + v)/2$
5. SI unit of acceleration → c. m/s^2
6. 1 km/h → e. 5/18 m/s

K • 3

Each carries 0.5 mark.

3 Multiple choice

- i. c. rest

K • 1

An object that doesn't change its position compared with its surroundings is at rest.

- ii. b. displacement

K • 1

Displacement is the straight-line distance from start to end, with its direction. The other three are velocities or speeds, measured in m/s, not in meters.

- iii. c. 15 m/s towards Pokhara

U • 1

A velocity needs a direction as well as a size. "15 m/s towards Pokhara" has both. The others give only how fast, so they are speeds.

- iv. c. zero

U • 1

Acceleration is the change in velocity per second. A steady velocity in a straight line doesn't change, so the acceleration is zero. A big velocity doesn't mean a big acceleration.

- v. b. 20 km/h

A • 1

Same direction, so subtract: $60 - 40 = 20$ km/h. That is why overtaking takes so long, and why it is dangerous on a narrow road: the motorcycle stays beside the truck for a long time. 100 km/h would be right only if they were going in opposite directions.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ Scalar.

- b. MARKING SCHEME

A • 1

✓ 20 m/s.

- c. MARKING SCHEME

U • 1

✓ In motion (she changes position compared with the trees).



5 Short answers

a. MARKING SCHEME

U · 2

- ✓ Any one difference, e.g. distance is the length of the whole path; displacement is the shortest straight-line distance from start to end in a particular direction.
- ✓ Any second difference, e.g. distance is a scalar, displacement a vector; or distance depends on the path, displacement only on the start and end points.

b. MARKING SCHEME

U · 2

- ✓ Any one difference, e.g. acceleration is the rate of increase of velocity; retardation the rate of decrease.
- ✓ Any second difference, e.g. in acceleration $v > u$ and a is positive; in retardation $v < u$ and a is negative; or a bus starting off, a bus braking.

c. MARKING SCHEME

U · 2

- ✓ We see the other bus from our moving bus, so we see its relative velocity.
- ✓ In the same direction the relative velocity is the difference of the speeds ($v_A - v_B$), which is small, so it seems to pass slowly.

d. MARKING SCHEME

K · 2

- ✓ When the body is in non-uniform motion (its velocity keeps changing).
- ✓ Average velocity = total displacement ÷ total time (s/t); or $(u + v)/2$ when the velocity changes steadily.

6 Long answers

a. ANSWER

K · 4

Acceleration is the rate of change of velocity: the change in velocity in one unit of time. $a = (v - u)/t$, where u is the initial velocity, v the final velocity and t the time taken. Its SI unit is m/s^2 . Retardation is the rate of decrease of velocity, when the final velocity is less than the initial velocity: negative acceleration. Example: a bus braking from 20 m/s to rest in 4 s has a retardation of 5 m/s^2 .

MARKING SCHEME

- ✓ Acceleration is the rate of change of velocity (change in velocity per unit time).
- ✓ $a = (v - u)/t$, with the symbols explained.
- ✓ SI unit m/s^2 .
- ✓ Retardation is the rate of decrease of velocity (negative acceleration), with any example, e.g. a bus braking.

b. ANSWER

U · 4

Same direction: $v_{AB} = v_A - v_B$. Example: two buses at 15 m/s and 10 m/s going the same way: $v_{AB} = 15 - 10 = 5 \text{ m/s}$.

Opposite directions: $v_{AB} = v_A + v_B$. Example: the same two buses going opposite ways: $v_{AB} = 15 + 10 = 25 \text{ m/s}$.

MARKING SCHEME

- ✓ Same direction: $v_{AB} = v_A - v_B$.
- ✓ Example, e.g. buses at 15 m/s and 10 m/s going the same way: $15 - 10 = 5 \text{ m/s}$.
- ✓ Opposite directions: $v_{AB} = v_A + v_B$.
- ✓ Example, e.g. the same buses going opposite ways: $15 + 10 = 25 \text{ m/s}$.

7 Numerical problems

a. ANSWER

A · 2

$s = 4.2 \text{ km} = 4200 \text{ m}$; $t = 7 \times 60 = 420 \text{ s}$. Average velocity = $s/t = 4200 \div 420 = 10 \text{ m/s}$.

MARKING SCHEME

- ✓ Changed to 4200 m and 420 s, and average velocity = s/t written.
- ✓ 10 m/s.



- b. ANSWER** A • 2
 $v = 0$, $a = -2 \text{ m/s}^2$, $t = 4 \text{ s}$. $a = (v - u)/t$: $-2 = (0 - u)/4$, so $u = 8 \text{ m/s}$.
MARKING SCHEME
✓ $a = (v - u)/t$ with $v = 0$ and $a = -2 \text{ m/s}^2$.
✓ $u = 8 \text{ m/s}$.
- c. ANSWER** A • 2
Same direction: $60 - 50 = 10 \text{ km/h}$. Opposite directions: $60 + 50 = 110 \text{ km/h}$.
MARKING SCHEME
✓ Same direction: 10 km/h .
✓ Opposite directions: 110 km/h .

8 Think

- ANSWER** HA • 2
Then their relative velocity is zero: compared with each other they are at rest, so the hose and the nozzle hang still and can be joined, just like two buses side by side at the same speed.
MARKING SCHEME
✓ At the same velocity their relative velocity is zero ($v_A - v_B = 0$).
✓ So they are at rest compared with each other, and the hose and nozzle stay still and can be joined.

9 Activity: How fast do we come to school? (Activity 6.1)

(not marked)

WHAT STUDENTS SHOULD FIND

Distances changed to meters and times to seconds before dividing. Someone who walks usually comes out at about 1–1.5 m/s; someone who comes by bus may be faster, even with all its stops. (Strictly, the road distance is a distance; the straight-line distance on a map gives the displacement.)

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	16	13	8	2	39





Unit 6 • Force and Motion: lever, pressure

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. lever
2. fulcrum
3. mechanical advantage
4. velocity ratio
5. efficiency
6. pressure
7. pascal
8. barometer

K • 4

Each carries 0.5 mark.

2 Label the diagram

- | | | |
|------------------------|-------------------------|-------|
| 1. from the gas supply | 4. air pressure P_1 | K • 3 |
| 2. colored water | 5. difference in levels | |
| 3. scale | 6. U-tube (glass) | |

Each carries 0.5 mark.

3 Multiple choice

- i. c. nutcracker

U • 1

In a nutcracker the nut (load) sits between the hinge (fulcrum) and your hand (effort). A dhiki is first-class; a shovel and a hammer hitting a nail are third-class.

- ii. b. velocity ratio

U • 1

VR depends only on the distances (where the fulcrum is). Friction changes the effort needed, so it changes the MA, the efficiency and the input work.

- iii. a. 760 mmHg

K • 1

Standard atmospheric pressure at sea level holds up a column of mercury 760 mm tall, about 100,000 Pa.

- iv. d. 588,000 Pa

A • 1

$P = h d g = 60 \times 1000 \times 9.8 = 588,000 \text{ Pa}$. Count the zeros carefully: the other options leave out one, two or three of them.

- v. b. compressed air

K • 1

Air brakes use compressed air, stored in tanks at high pressure, to push the brakes on.

4 Very short answers

- a. MARKING SCHEME

U • 1

✓ First-class lever (the fulcrum is between the load and the effort).

- b. MARKING SCHEME

K • 1

✓ Manometer.

- c. MARKING SCHEME

K • 1

✓ A pressure gauge.



5 Short answers

a. MARKING SCHEME

U • 2

- ✓ Some input work is always used up against friction at the fulcrum and turns into heat.
- ✓ So the output work is less than the input work, and $\text{output} \div \text{input} \times 100\%$ is less than 100%.

b. MARKING SCHEME

A • 2

- ✓ A wheelbarrow is a second-class lever with the fulcrum at the wheel; moving the load towards it shortens the load distance (the effort distance stays the same).
- ✓ By $E \times E.D. = L \times L.D.$, a shorter load distance needs a smaller effort.

c. MARKING SCHEME

U • 2

- ✓ The studs touch the ground over a small area, so the player's weight makes a large pressure under them.
- ✓ They sink into the ground and grip it, so the player doesn't slip.

d. MARKING SCHEME

U • 2

- ✓ The pressure of water increases with depth ($P = h \rho g$), so it is greatest at the bottom of the dam.
- ✓ A wider, thicker base is stronger and can stand that greater pressure.

6 Long answers

a. ANSWER

U • 4

Mechanical advantage (MA)	Velocity ratio (VR)
The ratio of load to effort.	The ratio of the velocity (or distance moved) of the effort to that of the load.
$MA = L \div E$	$VR = E.D. \div L.D.$ for a lever
Affected by friction: friction lowers it.	Not affected by friction.
Always less than VR in a real machine.	Always more than MA in a real machine.

MARKING SCHEME

- ✓ MA is the ratio of load to effort; VR is the ratio of the velocity (distance moved) of the effort to that of the load.
- ✓ $MA = L \div E$; $VR = E.D. \div L.D.$ for a lever.
- ✓ MA is affected (lowered) by friction; VR is not affected by friction.
- ✓ MA is always less than VR in a real machine. Any one difference per point.



b. ANSWER

A • 4

Take a container with a base of area A , filled to a height h with a liquid of density d , where the acceleration due to gravity is g .

Volume of the liquid: $V = A \times h$

Mass of the liquid: $m = d \times V = d \times A \times h$

Weight of the liquid (the force on the base): $W = mg = d \times A \times h \times g$

Pressure on the base:

$$P = \frac{W}{A} = \frac{d \times A \times h \times g}{A} = h d g$$

Hence proved: $P = h d g$.

MARKING SCHEME

- ✓ A container with base area A holds a liquid of density d to a height h ; volume of the liquid $V = A \times h$.
- ✓ Mass $m = d \times V = d \times A \times h$.
- ✓ Weight (force on the base) $W = mg = d \times A \times h \times g$.
- ✓ $P = W/A = (d \times A \times h \times g)/A = h d g$.

7 Numerical problems**a. ANSWER**

A • 2

$E \times E.D. = L \times L.D.$: $75 \times E.D. = 300 \times 25$, so $E.D. = 7500 \div 75 = 100$ cm.

MARKING SCHEME

- ✓ $75 \times E.D. = 300 \times 25$ (principle of the lever used).
- ✓ $E.D. = 100$ cm.

b. ANSWER

A • 3

$MA = L \div E = 900 \div 300 = 3$. $L.D. = 0.5$ m, so $E.D. = 2 - 0.5 = 1.5$ m and $VR = E.D. \div L.D. = 1.5 \div 0.5 = 3$. $\eta = MA \div VR \times 100\% = 3 \div 3 \times 100\% = 100\%$.

MARKING SCHEME

- ✓ $MA = 900 \div 300 = 3$.
- ✓ $E.D. = 1.5$ m, so $VR = 1.5 \div 0.5 = 3$.
- ✓ $\eta = 3 \div 3 \times 100\% = 100\%$.

c. ANSWER

A • 2

$P = h d g$, so $d = P/(h g) = 24,696 \div (2 \times 9.8) = 24,696 \div 19.6 = 1260$ kg/m³.

MARKING SCHEME

- ✓ $d = P/(h g) = 24,696 \div (2 \times 9.8)$.
- ✓ 1260 kg/m³.

8 Think**ANSWER**

HA • 2

Pressure is force $\div$ area. The elephant's weight is spread over four wide, flat feet, so the pressure under them is not very large. The woman's weight rests on the tiny tip of a heel, so the pressure there is far greater, enough to dent the wood.

MARKING SCHEME

- ✓ Pressure = force $\div$ area: it depends on the area as well as the weight.
- ✓ The elephant's weight is spread over a large area (small pressure); the heel puts the woman's weight on a tiny area (very large pressure).

9 Activity: Balancing a meter stick (Activity 6.3)

(not marked)

WHAT STUDENTS SHOULD FIND

Whenever the rule balances, the two products in a row come out equal: effort $\times$ effort distance = load $\times$ load distance, the principle of the lever. The heavier mass always hangs closer to the fulcrum.



See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **Walk Your Weight** (exhibit): Walk along the plank: the farther you are from the pivot, the more your weight turns it.
- **Simple Machines Around Us** (exhibit): Find the levers among the everyday tools, and where each one's fulcrum is.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	13	14	2	40

