National 5 Physics
Dynamics and Space
Homework
Exercises
Exercise 1

**Average and Instantaneous Speed**

1. Explain the difference between average and instantaneous speed.

2. State whether the following are *average speeds* or *instantaneous speeds*.
   
   a. The speed of a train travelling between Glasgow and Paisley.
   b. The speed of a car on a speedometer.
   c. The speed of a roller coaster at bottom of a loop.
   d. The speed of a car between two lamp-posts.
   e. The speed of a golf ball as it leaves the club.

3. Describe a method of measuring the instantaneous speed of a trolley in the lab. Your description should include
   
   a. A diagram of the apparatus
   b. The measurements taken
   c. Any calculations involved.

4. A train leaving Glasgow at 9.00 am arrives in Edinburgh at 10.15 am. The distance is 84 km.

   a. Calculate the average speed in kilometres per hour.

   b. Express the speed in metres per second.
5. A jet travels from London to New York at an average speed of 223 m/s. The flight time is 7 hours. Calculate the distance travelled by the jet.

6. A student carries out an experiment to measure the instantaneous speed of a toy car using the apparatus shown below.

![Diagram of the apparatus](image)

The length of the trolley is 30 cm. The time recorded on the timer is 0.15 s. Use the measurements to calculate the instantaneous speed of the trolley.

*End of exercise 1*
Exercise 2

Scalars and Vectors

1. Physical quantities can be categorised as either *scalar* or *vector*.
   
a. Describe what is meant by a *scalar* quantity.

   b. Describe what is meant by a *vector* quantity.

   c. Sort the following into a table with the headings *scalar quantity* and *vector quantity*.

<table>
<thead>
<tr>
<th>force</th>
<th>distance</th>
<th>displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>speed</td>
<td>time</td>
<td>velocity</td>
</tr>
</tbody>
</table>

2. During a race, a car makes 25 complete laps of a course of 5 km.
   
a. What is the total distance travelled by the car after 25 complete laps?

   b. What is the resultant displacement of the car after 25 complete laps?

[Turn over
3. An athlete runs 8 km due west then turns and runs 6 km due north as shown in the diagram.

![Diagram showing an athlete running 8 km west and then 6 km north]

a. What is the total distance that the athlete travelled?

b. By scale diagram or otherwise, find the resultant displacement of the athlete.

c. The run was completed in 75 minutes.
   
   i. Calculate the average speed of the athlete in km/h.

   ii. Calculate the average velocity of the athlete in km/h.

*End of exercise 2*
Exercise 3

Acceleration

1. State the definition of acceleration.

2. A Ford KA increases its velocity from 2 m/s to 16 m/s in 10s.
   A Peugot 106 takes 8s to accelerate to 11 m/s from rest.
   Show by calculation which car has the greater acceleration.

3. A car slows from 70 mph to 30 mph in 5 s when taking the exit from a motorway.
   a. Calculate the deceleration in mph / s.
   b. If 1 mile = 1.6 km, what is the deceleration in km/h/s?
   c. Calculate the deceleration in m/s².

4. During a game of ten-pin bowling, a player gives bowling ball an acceleration of 3 m/s² for 1.2 s.
   Assuming the bowling ball was accelerated from rest, calculate the final velocity of the bowling ball.

5. A supertanker travelling at 13 m/s decelerates at a rate of 0.03 m/s². How long does it take to come to a complete stop?

6. A rocket accelerates at 5.2 m/s² for 10 minutes to reach a final velocity of 6200 m/s. Calculate the initial velocity of the rocket.

End of exercise 3
Exercise 4

Velocity-time and speed-time graphs

1. The motion of a race car is recorded as follows:

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (m/s)</td>
<td>5</td>
<td>5</td>
<td>20</td>
<td>35</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>25</td>
<td>0</td>
</tr>
</tbody>
</table>

a. Using the graph paper provided, draw a speed time graph of the race car’s journey.

b. Using the graph you have drawn, describe the motion of the race car over the 80 seconds.

c. Using the graph you have drawn, calculate

   i. The acceleration between 10 and 40 s.
   ii. The total distance travelled by the race car.
   iii. The average speed during the 80 seconds.
2. The velocity-time graph shown below describes the motion of a ball which has been thrown straight up into the air then allowed to fall to the ground.

![Velocity-time graph](image)

a. At what time does the ball reach its maximum height?

b. Calculate the maximum height that the ball reaches.

c. Calculate the height from maximum to the ground.

d. Use your answers to b. and c. to calculate the height above the ground that the ball was thrown from.

*End of exercise 4*
Exercise 5

Weight, mass and gravitational field strength

1. Describe how a Newton Balance can be used to measure the size of a force.

2. A student takes two identical pieces of paper. She crumples one into a ball and leaves the other one as a flat sheet. The student then drops both pieces of paper. Which piece of paper will land first? Explain your answer.

3. Mass and weight mean different things.
   a. Explain what is meant by mass.
   b. What are the SI units of mass?
   c. Explain what is meant by weight.
   d. What are the SI units of weight?

4. Define the term gravitational field strength.
5. A pupil has a mass of 48 kg.

   a. Calculate the weight of the pupil on Earth.

   b. What would the mass of the pupil be on Mars?

   c. Calculate the weight that the pupil would be on Mars where the gravitational field strength is 4 N/kg.

6. A scientist predicts that a person of mass 75 kg will have a weight of 780 N on a newly-discovered planet. Calculate the gravitational field strength of this planet.

End of exercise 5
Exercise 6

Friction

1. Look at the cyclists in the picture below.

   ![Cyclists image]

   a. Identify **three** ways in which friction acting against the bicycles or cyclists has been reduced.

   b. On other occasions, it is useful to **increase** the amount of friction acting.

      i. Identify **two** places on a bicycle where friction is increased.

      ii. For each place, explain why friction should be increased.

   c. The cyclists find that as they start off, they can accelerate easily. After a while though, they have to pedal hard just to maintain a constant speed. Explain why this happens.

   *End of exercise 6*
Exercise 7

Newton’s First Law

1. a. Explain the term balanced forces.
   
b. What are balanced forces equivalent to?
   
c. State Newton’s First Law.

2. A weightlifter holds a bar as shown.

   The mass of the bar is 180 kg.

   a. Calculate the weight of the bar.
   
b. What size of force did the weightlifter apply to raise the bar at a constant speed?
   
c. What is the size of force that the weightlifter applies to hold the bar stationary?

3. Explain, using the theory of forces, how a seat belt can prevent injury in a car crash.

End of exercise 7
**Exercise 8**

**Resultant Force and Newton’s 2\textsuperscript{nd} Law**

1. A fully laden oil tanker of mass $6.5\times10^7$ kg sets off from its port on a bearing of $090^\circ$.
   Its engine produces a force of $4.0\times10^6$ N. A tugboat pushes against the tanker as shown with a force of $3.0\times10^6$ N.

   ![Diagram of tanker with forces](image)

   a. Using a scale diagram or otherwise, find the resultant force acting on the tanker.

   b. Calculate the initial acceleration of the tanker.

2. A car of mass 1500 kg accelerates at a rate of 2.3 m/s$^2$.
   The engine of the car provides a force of 4000 N.

   Calculate the size of the frictional force acting on the car.

   *[Turn over]*
3. A firework of mass 0.2 kg has an initial upwards thrust of 2.8 N.

   a. Calculate the weight of the firework.

   b. Draw a diagram and label the forces acting on the firework.

   c. Calculate the initial acceleration of the firework.

   d. As the firework ascends, its acceleration increases. Explain why the acceleration increases.

4. The speed-time graph for a sky-dive is shown below:

   a. Explain why the gradient of the graph is decreasing between 0 and 20 seconds.

   b. At what time is the parachute opened?

   c. What is the name given to the constant velocity reached during free-fall?

   End of exercise 8
Exercise 9

Projectile Motion

1. A javelin is launched horizontally at 5 m/s. It lands 15 metres horizontally from its launch point.

   a. Calculate the time that the javelin is in the air for.

   b. Calculate the final vertical velocity of the javelin.

   c. Using a scale diagram or otherwise, find the size of the final resultant velocity of the javelin and the angle of impact.
2. A ball rolls off a table top with a horizontal speed of 2.0 m/s. The ball hits the ground 0.3 seconds later.
   
   a. Calculate the horizontal distance that the ball lands from the table top.
   
   b. Calculate the final vertical speed of the ball.
   
   c. Sketch a velocity-time graph of the vertical motion of the ball.
   
   d. Use the graph to find the height of the table.

3. Explain how an artificial satellite such as the International Space Station remains in orbit around the Earth.
Exercise 10

Energy

1. In each of the cases below, state the main energy change involved for the vehicle.
   a. A rollercoaster carriage rolling up a slope to a high point.
   b. A skier skiing down a slope.
   c. A bus driving along a level road at a constant speed.

2. a. What is work done? Your answer should not be an equation!
   b. Calculate the work done by a horse when it uses a force of 800 N to pull a sled a distance of 150 m.

3. Copy and complete the table below. You must show full calculations for each problem.

<table>
<thead>
<tr>
<th>POWER(W)</th>
<th>WORK DONE(J)</th>
<th>TIME(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>
4. A roller coaster carriage has a mass of 300 kg when it is carrying a full load.

   a. Calculate the potential energy of the carriage when it is at the top of a drop, 30 m above the ground.
   b. At the bottom of the drop it is at a height of 2 m above the ground. Calculate its potential energy now.
   c. Calculate how much kinetic energy the carriage will have gained at this point.
   d. Calculate the increase in speed due to the drop (assuming no energy has been lost due to friction).

5. Name two quantities that affect a vehicle’s kinetic energy.

6. A winch pulls a crate up to a height of 4 m in a time of 20 s. If the crate has a mass of 100 kg, find the power of the motor.

7. Find the kinetic energy of a car of mass 800 kg travelling at 30 m/s.