Physics

Standard level

Paper 2

1 hour 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open the examination paper until instructed to do so.
- Answer all questions
- Answers must be written in the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

1. A student releases a small block of mass 2.0 kg from rest at the top of a smooth frictionless ramp. The block starts from a height of 3.0 m above the ground. At the bottom of the ramp, the block moves horizontally across a rough surface with a constant frictional force of 4.0 N acting against its motion.

(a) Calculate the speed of the block at the bottom of the ramp. [3]

.....
.....
.....
.....
.....
.....

(b) Determine the kinetic energy of the block at the bottom of the ramp. [2]

.....
.....
.....
.....

(c) Calculate the distance the block travels on the rough surface before coming to rest. [3]

.....
.....
.....
.....
.....
.....

(This question continues on the next page)

(d) State the principle of conservation of energy and explain how it applies to this situation. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

2. An airboat is a water vehicle propelled by a fan blowing a column of air behind the boat. A particular airboat has a total mass of 240 kg and has a fan that blows 16 kg of air per second at 5.0 m s^{-1} relative to the boat.

(a) The airboat is placed on the surface of a lake. Given that the boat floats, find the volume of water displaced by the airboat. The density of water is 1000 kg m^{-3}. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

The fan is turned on and the boat accelerates across the water.

(b) Given that the boat travels 8.0 m in 8.0 s, show that the average resistive force from the water on the boat is approximately 20 N. [4]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

3. A school decides to participate in the Allay Robotics Competition. The objective of the competition is to score points by launching "tetraballs" to the other side of the field and pushing them under a goal.
The robot the school has built uses a pneumatic flap system to push balls into the goal. The pneumatics system is powered by a cylindrical gas tank 2.50 cm in radius and 15 cm in length. The tank initially stores 0.350 g of air at atmospheric pressure.

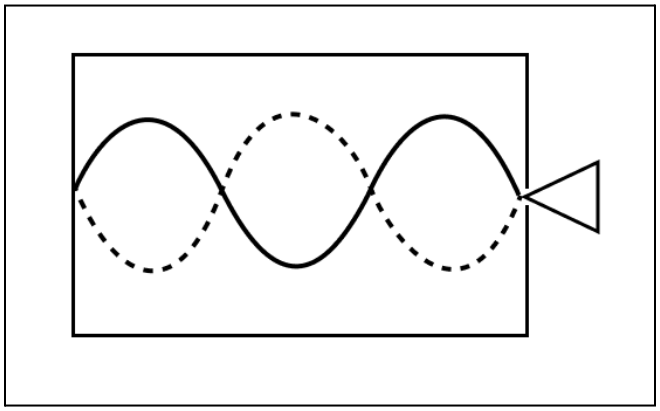
(a) Ryan uses an air pump to fill the tank to a pressure of 170 kPa. Find the average outward force acting on the wall of the tank. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) After the tank is filled, its mass increases by 0.210 g. Given that the molar mass of air is approximately 29.0 g mol^{-1}, find the temperature of the tank after it has been filled in °C. [3].

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

4. A microwave oven functions by reflecting microwave radiation off the metal walls of the oven to form a standing wave, an example of which is shown below.



(a) A particular microwave oven uses microwaves of wavelength 12 cm. If a standing wave at the 5th harmonic is created inside the microwave, find the width of the microwave chamber. [1]

. . . . . .
. . . . . .

A microwave heats up food using electromagnetic radiation to induce vibration in water molecules.

(b) Estimate the resonant frequency of a water molecule. [1]

. . . . . .
. . . . . .

(This question continues on the next page)

Two small potato cubes with a mass of 5.0 g each are placed inside a microwave oven. Cube A is placed 6.0 cm away from the oven wall, and cube B is placed 9.0 cm away.

(c) Explain which cube is not heated up when the microwave is turned on. [2]

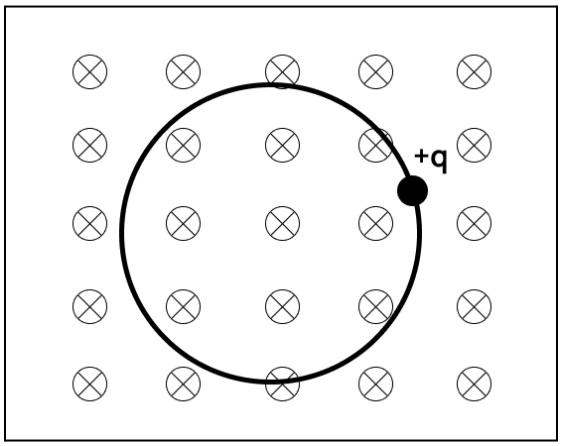
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(d) The other cube increases in temperature by 30°C. Given that potatoes and water have specific heat capacities of 3350 J kg^{-1} K^{-1} and 4200 J kg^{-1} K^{-1} respectively, find the energy transferred to the potato cube. [1]

. . . . . .
. . . . . .

RevisionDojo

5. A particle of mass m and charge $+q$ moves with constant velocity v in a magnetic field of strength B as shown below.



(a) State whether the particle moves clockwise or anticlockwise. [1]

.....
.....

(b) Find the radius r of the path in terms of q, B, and its momentum p. [2]

.....
.....
.....
.....

(c) Find the period of the circular motion and outline whether it is dependent on the particle's velocity. [2]

.....
.....
.....
.....

6. In a fission reactor, uranium-235 $^{235}_{92}U$ *undergoes induced fission to produce caesium-137* $^{137}_{55}Cs$, rubidium-96 $^{96}_{37}Rb$, and several neutrons.

(a) State the number of neutrons emitted by uranium-235 fission. [1]

.....
.....

(b) Outline the purpose of the moderator in a nuclear fission reactor. [2]

.....
.....
.....
.....

(This question continues on the next page)

The following data are given:

Nuclide	Atomic mass / amu
$^{233}_{92}U$	235.043923
$^{137}_{55}Cs$	136.907084
$^{96}_{37}Rb$	95.934284

(c) Outline the energy transformations and explain why the total energy released in nuclear fission is much greater than in chemical reactions. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the next page)

(d) A particular nuclear plant consumes 7.0×10^{-7} of $^{235}_{92}U$ per second. Find the power, in MW, generated by this nuclear plant. [3]

(e) Find the mass of water boiled per second by this nuclear plant. The specific latent heat of vaporization of water is 2268 J g^{-1}. [1]

7. Stars undergo various physical processes throughout their life cycle, which influence their structure, energy production, and eventual fate.

(a) State the physical process that is the source of energy in stars and describe the conditions necessary for this process to occur. [3]

(This question continues on the next page)

(b) Explain how the mass of a star affects its evolution and final fate. [3]

(c) A star is located at a distance of 4.0 parsecs from Earth. Calculate the expected stellar parallax angle in arc-seconds. [2]

(d) Describe the forces acting within a stable main sequence star and explain how these forces relate to the star's stability. [1]