Question 1

(*a*) State Boyle's law.

Question 2

1. The laws of equilibrium for a set of co-planar forces acting on a metre stick were investigated by a student. She first found the centre of gravity of the metre stick and then determined its weight as 1.3 N.

How did the student find the centre of gravity of the metre stick? The centre of gravity was at the 50.3 cm mark rather than the mid-point of the metre stick. Explain.

The metre stick was suspended from two spring balances graduated in newtons. The student made use of a set of three weights, which she hung from the metre stick. She adjusted them until the metre stick was at equilibrium. How did the student ensure that the system was at equilibrium?

Draw a diagram of the experimental arrangement that the student used. (18)

The student recorded the positions of the forces acting on the metre stick and the direction in which each force was acting.

Position of force on metre stick/cm	11.4	21.8	30.3	65.4	80.0
Force/N	2.0	3.0	5.7	4.6	4.0
Direction	downward	downward	upward	upward	downward

Taking the moments of the forces about the mid-point of the metre stick (50 cm mark), use the student's data to calculate

(i) the total of the clockwise moments
(ii) the total of the anti-clockwise moments.

Explain how these results verify the laws of equilibrium. (22)

Question 3

2. In an experiment to verify Boyle's law, a student took the set of readings given in the table below.

X	120	160	200	240	280	320
Y	52	39.1	31.1	25.9	22.2	19.6

What physical quantities do X and Y represent? (6)
Name the units used when measuring these quantities. (4)

Draw a labelled diagram of the apparatus that the student used in the experiment.
Describe the procedure he used to obtain these readings. (15)

Use the data in the table to draw an appropriate graph on graph paper.
Explain how your graph verifies Boyle's law. (15)

Question 4

6. (i) State Newton's law of universal gravitation. (6)

(ii) Explain what is meant by angular velocity. Derive an equation for the angular velocity of an object in terms of its linear velocity when the object moves in a circle. (9)

The International Space Station (ISS), shown in the photograph, functions as a research laboratory and a location for testing of equipment required for trips to the moon and to Mars. The ISS orbits the earth at an altitude of 4.13×10^5 m every 92 minutes 50 seconds.

(iii) Calculate (*a*) the angular velocity, (*b*) the linear velocity, of the ISS. (12)

(iv) Name the type of acceleration that the ISS experiences as it travels in a circular orbit around the earth. What force provides this acceleration? (6)

(v) Calculate the attractive force between the earth and the ISS. Hence or otherwise, calculate the mass of the earth. (15)

(vi) If the value of the acceleration due to gravity on the ISS is 8.63 m s^{-2}, why do occupants of the ISS experience apparent weightlessness? (3)

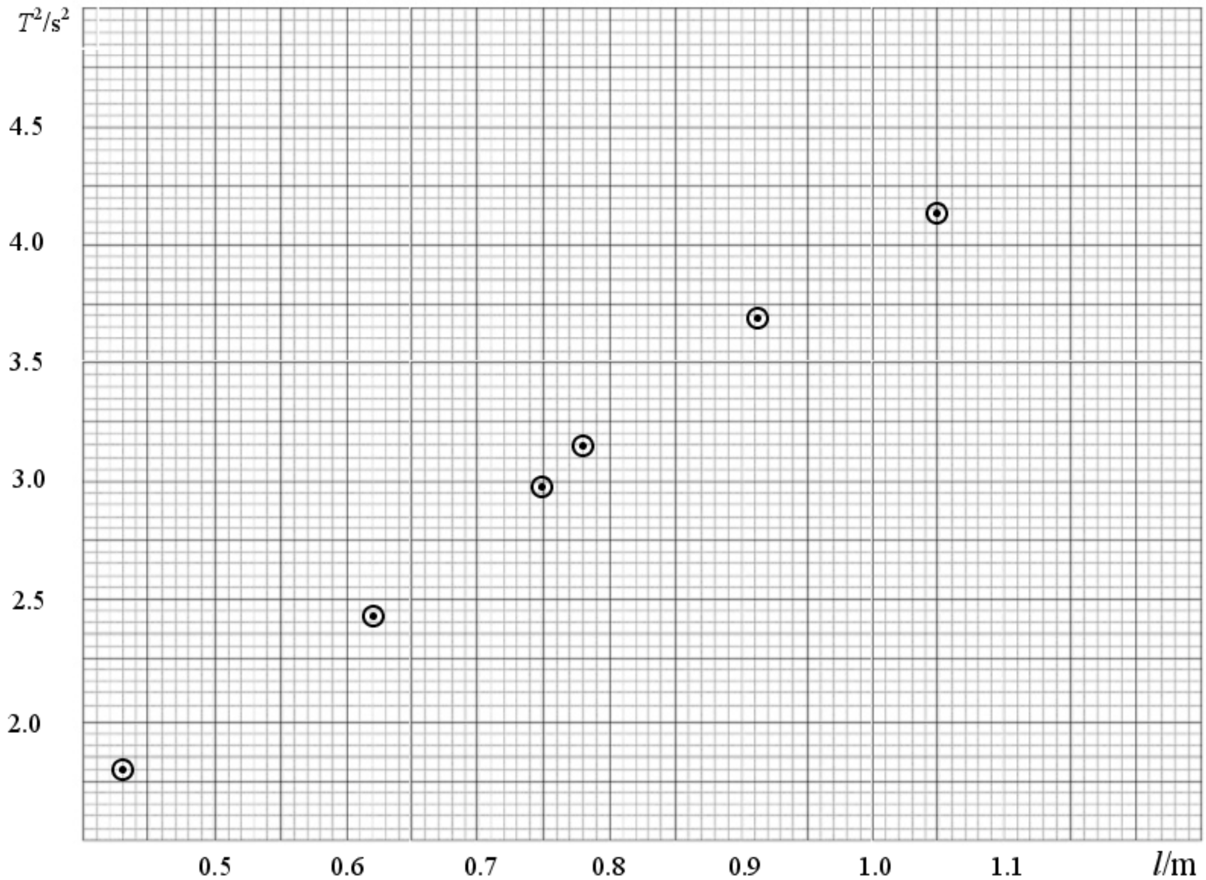
(vii) A geostationary communications satellite orbits the earth at a much higher altitude than the ISS. What is the period of a geostationary communications satellite? (5)

(mass of ISS = 4.5×10^5 kg; radius of the earth = 6.37×10^6 m)

Question 5

1. In an experiment to measure the acceleration due to gravity using a simple pendulum, a student obtained values for the length *l* of the pendulum and the corresponding values for the periodic time *T*.

The student plotted the following points, based on the recorded data.



Describe how the student obtained a value for the length of the pendulum and its corresponding periodic time. (18)

Draw the appropriate graph on this examination paper and use it to calculate a value for *g*, the acceleration due to gravity. (15)

Give two factors that affect the accuracy of the measurement of the periodic time. (7)

Question 6

2. During an experiment to verify Boyle's law, the pressure of a fixed mass of gas was varied. A series of measurements of the pressure p and the corresponding volume V of the gas was recorded as shown. The temperature was kept constant.

p/kPa	325	300	275	250	200	175	150	125
V/cm^3	12.1	13.0	14.2	15.5	19.6	22.4	26.0	31.1

Draw a labelled diagram of the apparatus used in the experiment.

How was the pressure of the gas varied during the experiment?

Describe how the pressure and the volume of the gas were measured.

Why should there be a delay between adjusting the pressure of the gas and recording its value? (22)

Draw a suitable graph to show the relationship between the pressure and the volume of a fixed mass of gas. Explain how your graph verifies Boyle's law. (18)

Question 7

(*a*) State the law of flotation. (7)

Question 8

(*b*) The head of a thumbtack has an area of 500 mm^2.
Its point has an area of 0.3 mm^2.
The pressure exerted at the head of the thumbtack is 12 Pa.
What is the pressure exerted at the point of the thumbtack? (7)

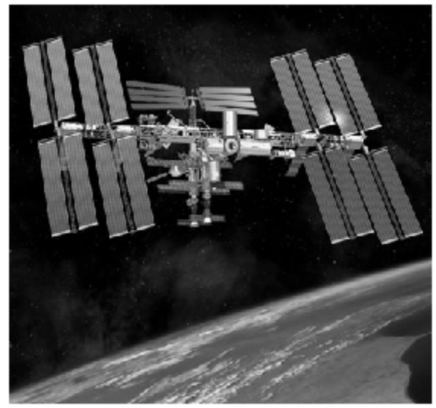
Question 9

6. State Newton's law of universal gravitation. (6)

The international space station (ISS) moves in a circular orbit around the equator at a height of 400 km.

What type of force is required to keep the ISS in orbit?

What is the direction of this force? (6)



Calculate the acceleration due to gravity at a point 400 km above the surface of the earth.
An astronaut in the ISS appears weightless.
Explain why. (14)

Derive the relationship between the period of the ISS, the radius of its orbit and the mass of the earth.

Calculate the period of an orbit of the ISS. (18)

After an orbit, the ISS will be above a different point on the earth's surface.

Explain why.

How many times does an astronaut on the ISS see the sun rise in a 24 hour period? (14)

(gravitational constant = 6.6×10^{-11} N m^2 kg^{-2};
mass of the earth = 6.0×10^{24} kg; radius of the earth = 6.4×10^6 m)

Question 10

1. A student investigated the laws of equilibrium for a set of co-planar forces acting on a metre stick.

The student found that the centre of gravity of the metre stick was at the 50.4 cm mark and its weight was 1.2 N.

How did the student find (i) the centre of gravity, (ii) the weight, of the metre stick?

Why is the centre of gravity of the metre stick not at the 50.0 cm mark?

The student applied vertical forces to the metre stick and adjusted them until the metre stick was in equilibrium.

How did the student know that the metre stick was in equilibrium? (19)

The student recorded the following data.

position on metre stick/cm	11.5	26.2	38.3	70.4	80.2
magnitude of force/N	2.0	4.5	3.0	5.7	4.0
direction of force	down	up	down	up	down

Calculate:
(i) the net force acting on the metre stick
(ii) the total clockwise moment about a vertical axis of the metre stick
(iii) the total anti-clockwise moment about a vertical axis of the metre stick.

Use these results to verify the laws of equilibrium. (21)

Question 11

(a) State Archimedes' principle. (7)

Question 12

(b) Why is it easier to turn a nut using a longer spanner than a shorter one? (7)

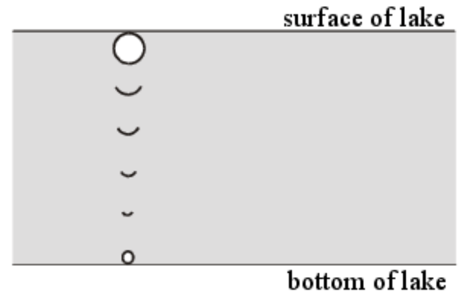
Question 13

(a) Define pressure. (6)

Is pressure a vector quantity or a scalar quantity? Justify your answer. (6)

State Boyle's law. (6)

A small bubble of gas rises from the bottom of a lake. The volume of the bubble increases threefold when it reaches the surface of the lake where the atmospheric pressure is 1.01×10^5 Pa. The temperature of the lake is 4 °C.



Calculate
- (i) the pressure at the bottom of the lake;
- (ii) the depth of the lake. (10)

(acceleration due to gravity = 9.8 m s^{-2}; density of water = 1.0×10^3 kg m^{-3})

Question 14

(a) A container contains 5.0 kg of water. If the area of the base of the container is 0.5 m^2 calculate the pressure at the base of the container due to the water.
(acceleration due to gravity = 9.8 m s^{-2}) (7)

Question 15

(b) State Boyle's law. (7)

Question 16

(a) State Boyle's law. (7)