In addition to the 1 hour, candidates are allowed a reading time of 10 minutes. Candidates must NOT write in their answer booklets during this time.

READ THE FOLLOWING DIRECTIONS CAREFULLY

1. Answer ANY THREE questions.
2. ALL WORKING MUST BE SHOWN in your answer booklet, since marks will be awarded for correct steps in calculations.
3. The use of non-programmable calculators is allowed.
4. Mathematical tables are provided.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO
1. (a) Explain with the aid of a diagram the operation of a simple magnetic relay. 

(b) Figure 1 shows the starting circuit of a car in which a low current through the ignition switch operates a relay allowing a large current to flow through thick conductors to the starter motor. The equivalent circuit when the relay is closed is shown in Figure 2.

![Figure 1](image1)

Given that a 12 V battery supplies 400 A to the motor and the resistances of the conducting wires in this circuit are as shown, calculate

(i) the p.d. across the starter motor
(ii) the power being supplied by the battery
(iii) the power being dissipated in the conducting wires
(iv) the power used by the starter motor to crank the car engine.

(12 marks)

Total 20 marks
2. (a) Define pressure and give its units. Describe with the aid of a diagram an experiment to demonstrate that the pressure at all points on the same horizontal level in a fluid at rest is the same. (8 marks)

(b) Figure 3 shows a sketch of a hydraulic jack which can be used to lift heavy objects.

![Hydraulic Jack Diagram]

Figure 3

(i) Given $A_1 = 0.002 \text{ m}^2$. What pressure is exerted on the fluid if $F_1 = 1000 \text{ N}$?

(ii) What is the area $A_2$ if this applied force raises a van weighing $10^5 \text{ N}$?

(assume that pressure drops due to the weight of liquid in the jack are negligible.) (6 marks)
(c) The tube shown in Figure 4 is used to siphon water from container A to container B.

![Diagram of siphoning](image)

**Figure 4**

What is the pressures at Points 1, 2 and 3 if the end of the tube which is inserted in Container B is closed just before siphoning begins?

Atmospheric Pressure = $1.013 \times 10^5$ Pa  
Density of water = $1000$ kg m$^{-3}$  

(6 marks)

Total 20 marks

3. (a) (i) Air is pumped into a car tyre to inflate it. Use the kinetic theory to explain how the air inside the tyre exerts the pressure which keeps the tyre inflated.

(ii) As the car travels, the temperature of the air inside the tyre is heated. Explain, again using the kinetic theory, what happens to the particles when this occurs.

(8 marks)

(b) (i) The car tyre contains air initially at a pressure of $195$ kPa. After travelling several kilometres, the temperature of the air inside the tyre rises from $30^\circ C$ to $70^\circ C$. If the tyre is rigid and does not expand, calculate the new pressure inside the tyre.

(ii) Consider a different tyre under identical conditions to those given in section (i). This tyre is more elastic and its volume increases by $10\%$ when the temperature of air inside it increases from $30^\circ C$ to $70^\circ C$. Calculate the final pressure in the second tyre.

(iii) Based on your results for sections (b) (i) and (b) (ii) above, state whether it is preferable to have rigid tyres or more elastic tyres for prolonged high speed driving.

(9 marks)

(c) What is the relationship between the force due to pressure on the inside of a tyre and the reaction force of the ground on the tyre? Explain how you arrived at your answer.

(3 marks)

Total 20 marks
4. (a) Describe an experiment to verify the laws of reflection. (8 marks)

(b) Figure 5 is a magnified view of the cross section of one track of a compact disk (CD) and its read head.

![Diagram of compact disk cross section]

Figure 5

Information is stored on the CD as a series of ‘hills’ and ‘valleys’ stamped into the aluminium mirror. The information is read by shining light from a laser source at X through the clear plastic layer so that it is reflected towards the sensor at Y, which has a very tiny opening.

(i) If the laser light beam follows the path shown in Figure 6, below, calculate the refractive index of the clear plastic. (5 marks)

![Diagram of compact disk cross section]

Figure 6

GO ON TO THE NEXT PAGE
(b) (ii) The track moves to the left (read head does not move) so that EF becomes the reflecting surface (see Figure 6). With the aid of a diagram showing the beam reflected from surface EF through the plastic and into the air, explain why the emerging beam will miss the sensor.  

(7 marks)

Total 20 marks

5. (a) State Newton’s Second Law of motion. Use Newton’s Second Law to explain the existence of the force of gravity on a falling object. Describe an experiment in which a simple pendulum is used to measure ‘g’, the acceleration due to gravity. 

(8 marks)

(b) Consider the action of kicking an initially stationary soccer ball so that it travels through the air, hits the goal post and rebounds. We can treat it as an example of the application of Newton’s Second Law.

(i) The ball has a mass of 0.44 kg and leaves the kicker’s foot with an initial velocity of 50 ms⁻¹. Calculate the momentum of the ball immediately after it has been kicked.

(ii) Calculate also the kinetic energy of the ball immediately after it has been kicked.

(iii) Identify the energy transformations that take place when the ball strikes the goal post and rebounds.

(iv) Is kinetic energy lost in the collision between the football and the goal post? Explain your answer.

(v) Explain why, “in real life”, the ball would not travel at constant speed but would slow down as it goes farther and farther from the kicker.

(vi) Draw a simple sketch, without numbers, of a velocity time diagram that shows the slowing down of the ball during its motion through the air. 

(12 marks)

Total 20 marks

END OF TEST