Rishi Valley School

Physics Home Work Assignment 03-11-2018

Introductory Rigid Body Mechanics, Fluid Mechanics, Heat, Light

1. Give concise answers with an emphasis on clarity.
2. Draw neat sketches, diagrams. Diagrams without labels and captions are incomplete. Graphs without labels and units on axes are incomplete. Numerical answers without units are incomplete.

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1 Mechanics

1.1 Laws of Mechanics

a) State the Laws of Physics in Mechanics that we have learnt so far? What are your thoughts on the significance of learning these laws well?

1.2 Problems on Kinematics

a) The two diagrams show the dimensions of a rectangular block being measured using a ruler. They are not shown full sie. Use the scales shown to find the length and width of the block, giving your answers in cm.

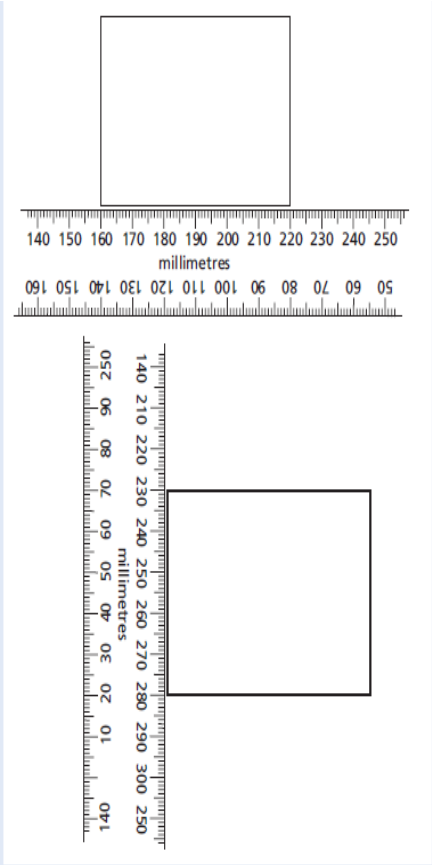

Figure 1: Problem 1

It is known that when the block was made it was cut from a piece of metal 2.0 cm thick. Calculate the volume of the block.

Another block has a volume of 20 cm^3. The diagram shows the reading when the block is placed on a balance. Find the density of this block.

b) The top graph shows the position-time graph for a girl's bicycle ride and the bottom graph gives the axes for the corresponding speed/time graph.

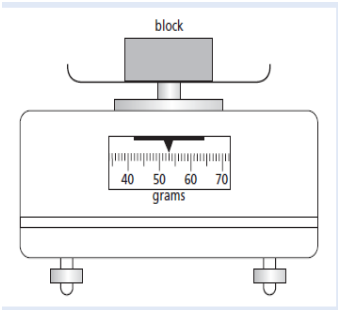

Figure 2: Problem 1 (Kinematics)

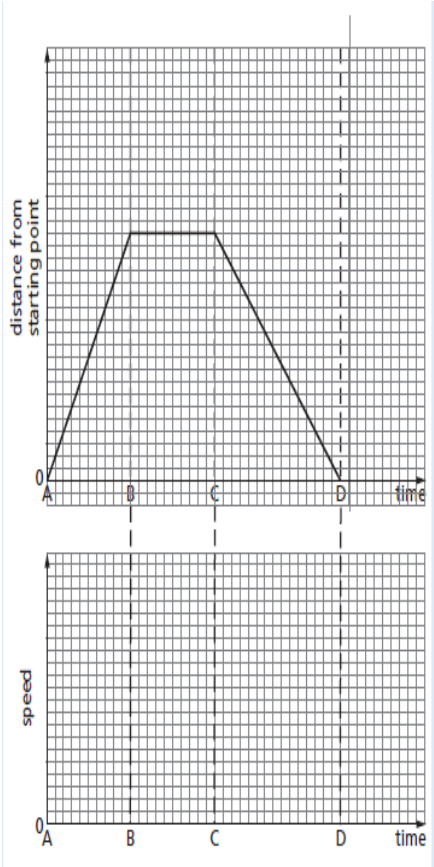

Figure 3: Problem 2 (Kinematics)

Look at the position-time graph. Answer the following questions for the time interval AB; 1) What can you say about the speed of the bicycle? 2) On a copy of the speed-time axes on the bottom graph, draw a thick line that could show the speed during AB.

On your copy of the speed-time axes 1) draw a thick line that could show the speed during BC. 2) draw a thick line that could show the speed during CD.

How far from her starting point is the girl when she has finished her ride.

c) In a training session, a racing cyclist's journey is in three stages

STAGE 1 He accelerates uniformly from rest to 12 m/s in 20 s.

STAGE 2 HE cycles at 12 m/s for a distance of 4800 m.

STAGE 3 He decelerates uniformly to rest.

The whole journey takes 500 s.

a) Calculate the time taken for STAGE 2; b) On a copy of the grid below, draw a speed - time graph of the cyclist's ride; c) Show that the total distance travelled by the cyclist is 5400 m; d) Calculate the average speed of the cyclist.

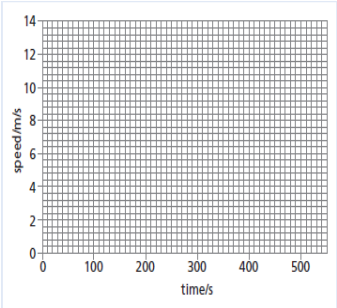

Figure 4: Problem 3 (Kinematics)

d) A large plastic ball is dropped from the top of a tall building. The diagram shows the speed time graph for the falling ball until it hits the ground.

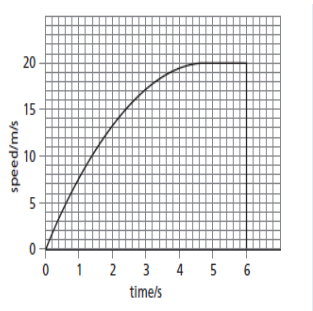

Figure 5: Problem 4 (Kinematics)

From the graph estimate 1) the time during which the ball is travelling with terminal velocity; 2) the time during which the ball is accelerating; 3) the distance fallen while the ball is travelling with terminal velocity; 4) the height of the building.

Explain in terms of the forces acting on the ball, why 1) the acceleration of the ball decreases,; 2) the ball reaches terminal velocity.

1.3 Problems on Dynamics

a) An object of weight W is suspended by two ropes from a beam, as shown in the diagram. The tensions in the rope are 50 N and 86 N. Consider the free body diagra, of the weight. Indicate the external contact forces on the weight? Indicate the external non-contact force on the body.

b) The diagram shows a model car moving clockwise around a horiontal circular track. A force acts on the car to keep it moving in a circle. Draw an arrow on a copy of the diagram to show the direction of this force.

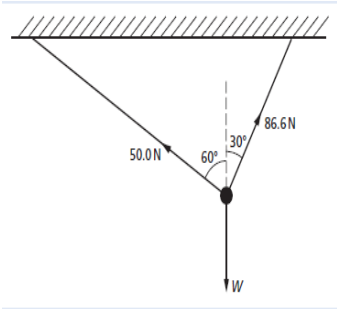

Figure 6: Problem 1 (Dynamics)

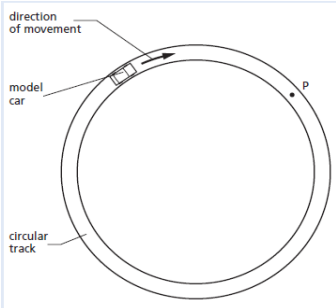

Figure 7: Problem 2 (Dynamics)

c) The diagram shows the free body diagram of a trolley on an inclined plane. What is the external contact force on the trolley, Where is it coming from? What is the external non-contact force on the trolley. Assume there is friction, will this be a contact or non-contact external force?

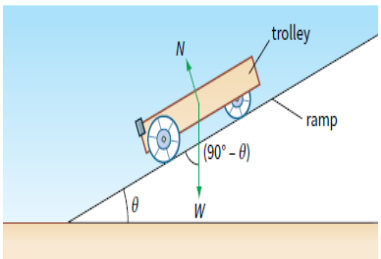

Figure 4.10 A force diagram for a trolley on a ramp.

Figure 8: Problem 3 (Dynamics)

2 Fluid Mechanics

2.1 Variation of Pressure in Fluid Statics

a) Write down the derivation of the equation $P_b - P_a = h\rho g$. What laws did you use to derive this equation.

b) The mercury barometer shows a reading of 0.76 m at Chennai. Draw a sketch showing the mercury barometer. Use the above formula to calculate the atmospheric pressure (in N/m^2) at sea level. What data do you need? Mention the units of this data that you are using.

c) 1) On a copy of the left hand barometer carefully mark the distance that would have to be measures in order to find the value of the atmospheric pressure; 2) A small quantity of air is introduced into X. Now a) State what happens to the mercury level in the tube. b) In terms of the behavious of the air molecules, explain your answer to the earlier (a) question. 3) The space above the mercury in the right hand barometer is a vacuum. On a copy of the right hand diagram mark the level of the mercury surface in the tube.

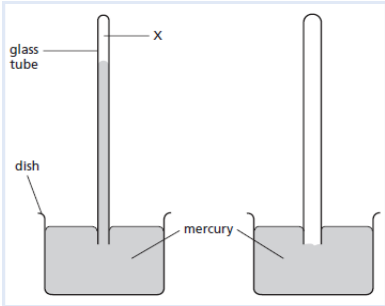

Figure 9: Problem 2 (Variation of Pressure in Fluids)

4) The left hand tube now has air above the mercury; the right hand has a vacuum. Complete the table using the words chosen from the list given to indicate the effect of changing the external conditions.

rises falls stays the same

change	effect on the level of the mercury in the left-hand tube	effect on the level of the mercury in the right-hand tube
atmospheric pressure rises		
temperature rises		

Figure 10: Problem 2 (Variation of Pressure in Fluid Statics)

2.2 Archimedes Principle

a) State Archimedes Principle of floatation. Write down the steps of a *thought experiment* to verify Archimedes Principle. What are the laws of Physics that you have used in this derivation?

2.3 Definition of a Fluid

a) The forces of the fluid act perpendicular to the surface of the object submerged in a static fluid. How will you justify this statement?

3 Heat

3.1 Kinetic Theory of Heat

a) What is our current understanding of the idea that a body possesses energy in the form of heat? Explain separately for the cases when the body is a solid/liquid/gas?

b) Explain on the basis of Kinetic theory, what happens when we put our hand near a furnace; When a vessel of hot water is heated by a hot flame; how does the tea cool down after we pour it on a saucer, what happens when we blow air on the tea; why does the cycle pump become hot after we finish pumping air into our bicycle tyres.

3.2 Laws of Physics

a) We have discussed two laws of physics concerning this topic of Heat. To recall and refresh your memory, the first law is the Law of Conservation of Energy. Can you state/explain this Law? Do you remember the statement of the Second Law (the so

called Second Law of thermodynamics). State the implication of the Second Law that we discussed in the Class.

b) How can you convert electrical energy into heat energy? What is the efficiency of this conversion? Can heat energy be converted into Electricity? How? Can this be 100 % i.e., Can all the heat energy be converted into Electrical Energy?

3.3 Thermal Expansion

a) Write down clearly the formulae that give us the final lengths, areas and volumes of solid objects when heated from an initial temperature T_i to a final temperature T_f. Write down the separately the formulae for increase in length ΔL. What is the material property value that you need for the above calculation? What is the unit for the Coefficient of thermal expansion of a solid? How will you define the Coefficient of thermal expansion of a solid?

b) A steel rod is 3.000 cm in diameter at 25 centigrade. A brass ring has an interior diameter of 2.992 cm at 25 centigrade. At what common temperature will the ring just slide onto the rod. (Brass $\alpha = 19 \times 10^{-6}$, Steel $\alpha = 11 \times 10^{-6}$).

c) When the temperature of a copper penny is raised by 100 degree centigrade, its diameter increases by 18 %. To two significant figures give the per cent increase in the a) area of the face b) thickness c) volume and d) mass of the penny. Also calculate the coefficient of linear expansion.

d) Consider a mercury in glass thermometer. Assume that the cross section of the capillary isconstant at A_0, and that V_0 is the volume of the bulb of mercury at 0 degree centigrade. If the mercury just fills the bulb at 0 degree centigrade, show that the length of the mercury column in the capillary at the temperature t degree centigrade is

$$l = \frac{V_0}{A_0}(\beta - 3\alpha)t$$

that is, proportional to the temperature. Here β is the volume coefficient of expansion of mercury and α is the linear coefficient of expansion of glass.

4 Light

4.1 Laws of Physics

a) What are the *Laws of Physics* related to Light that we have learnt. (Mention as much as you know of the laws of Refraction also). State these *Laws* carefully. Why are we calling them *Laws*.

b) What do you think have been the advantages for you for learning these Laws(related to Light) and having a clear idea of what these Laws mean?

4.2 Ray Diagrams in Plane mirrors and Image formation

a) Show two plane mirrors placed at right angles to each other. Show a point object. Draw some position of the eye. Show the three images that are visible to the eye. Use a ruler, protractor or compass (if you have learnt the geometric constructions in your Math class) and accurately show the light ray that starts at the object and reaches the eye and explain all the three images.

b) Now place the plane mirrors at an angle of 60 degrees to each other. Show a point object. Show all the images formed. How many images does the eye see. Choose a couple of images and trace the light rays that explain why the eye sees these images.

c) How tall must a vertical mirror be if a person 6 ft high is to be able to see her entire length? Assume that her eyes are 4 inches below the top of her head. Draw the ray diagrams and place the mirror in the most appropriate way.

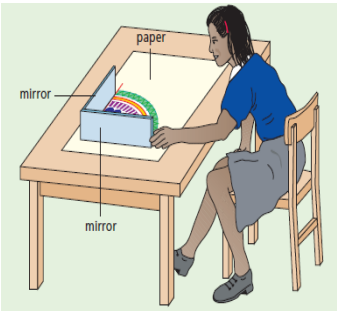

Figure 11: Problem 1 (Ray Diagrams in Plane Mirrors)

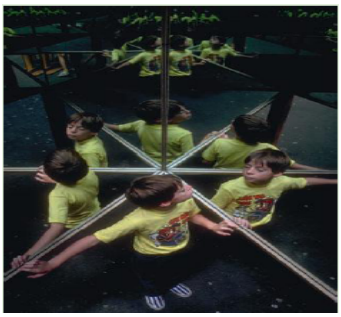

Figure 12: Problem 2 (Ray Diagrams in Plane Mirrors)