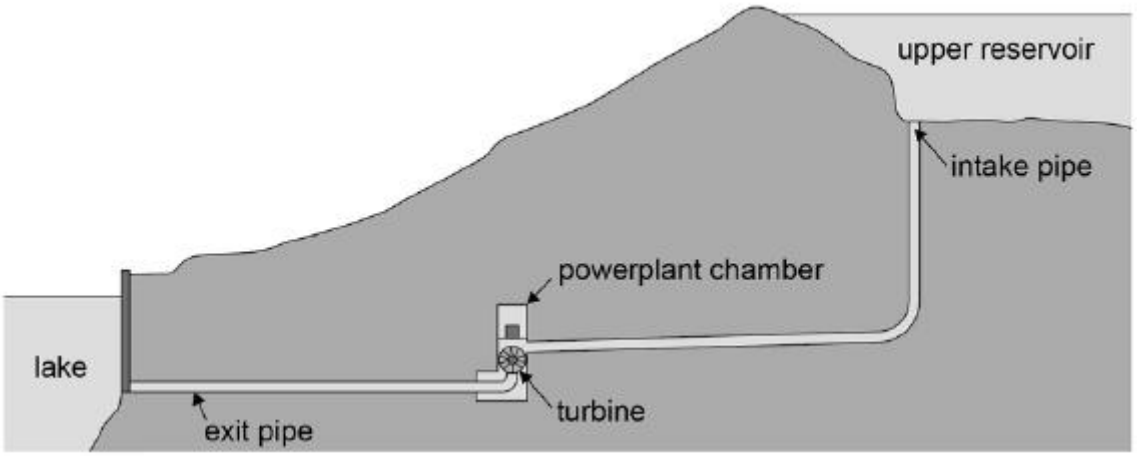
Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

The diagram below shows a possible design for a pumped storage system used to generate electricity.



Water from the upper reservoir is to fall through a vertical distance of 90 m before reaching a powerplant chamber. The water rotates a turbine in the chamber that drives an electricity generator. After leaving the turbine, the water travels through an exit pipe to a lake.

(a) Show that the maximum possible speed of the water as it arrives at the turbine is about 40 m s^{-1}.

(2)

(b) The volume of water flowing into the turbine every second is 3.5 m^3.

Estimate the radius of the intake pipe that is required for the system.

pipe radius = _____ m

(2)

(c) The water leaves the powerplant chamber at a speed of 12 m s^{-1}.

Calculate the maximum possible power output of the turbine and generator.
Give an appropriate unit for your answer.

density of water = 1000 kg m^{-3}

Maximum power output = _____ unit = _____

(4)

(d) Energy losses are estimated to reduce the output power for the turbine and generator to 60% of the value you calculated in part **(c)**.

Explain **two** possible reasons for this energy loss.

1. _____

_____

_____

2. _____

_____

_____

(2)

(Total 10 marks)

Q2.

A car is designed to break the land speed record. The thrust exerted on the car is 230 kN at one instant of its motion. The mass of the car at this instant is 11 000 kg.

(a) The acceleration of the car at this instant is 2.9 m s^{-2}.

Calculate the air resistance acting on the car.

air resistance =_____ N

(3)

(b) The thrust on the car remains constant as the speed increases.

Explain why the acceleration decreases and eventually reaches zero.

_____

_____

_____

_____

_____

(2)

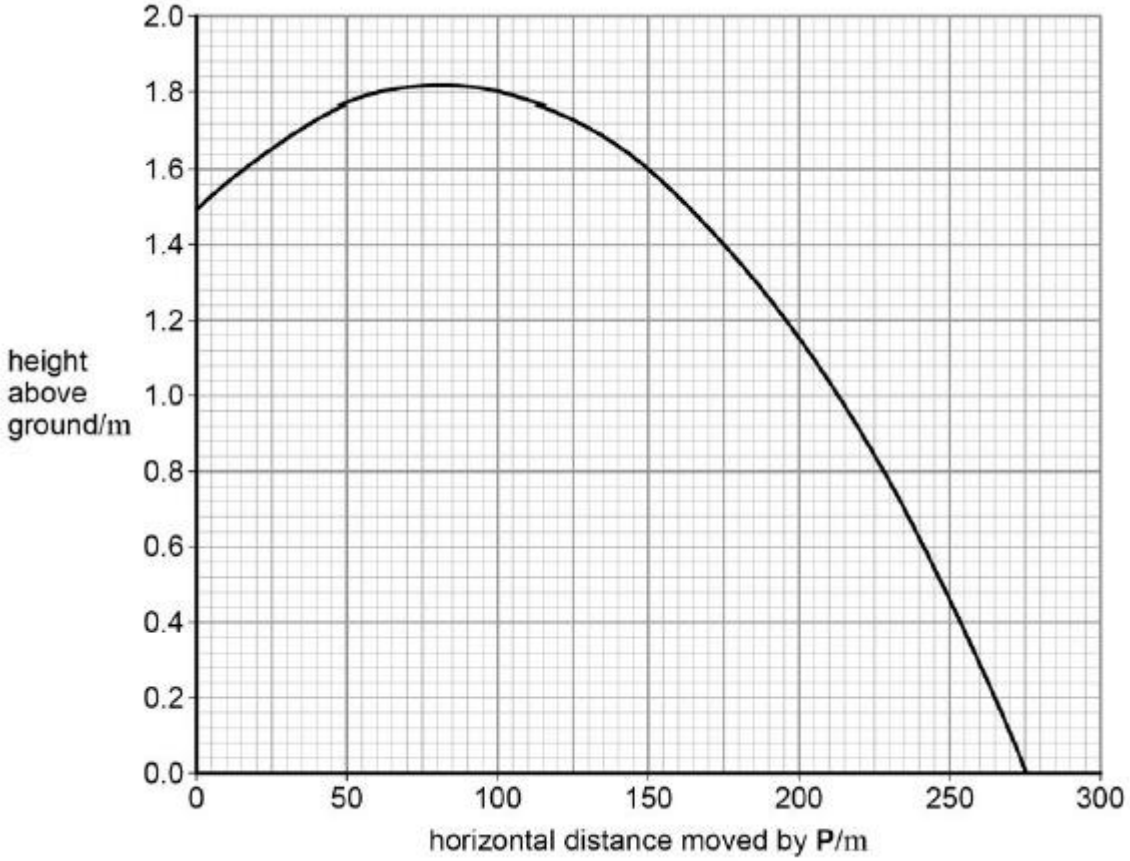
(c) A supersonic car is attempting to break the land speed record on a horizontal track. When it is travelling at 320 m s^{-1}, a small part **P** that is 1.5 m above the ground becomes detached from the car. The initial vertical velocity of **P** is 2.5 m s^{-1} in the upwards direction.

Calculate the time taken for the small part **P** to reach the ground.
Assume that air resistance has a negligible effect on the vertical motion.

time = _____ s

(3)

(d) The graph below shows the path that **P** would follow from the instant that it became detached if there were no air resistance in the horizontal direction.



In practice, air resistance is not negligible in the horizontal direction.

Draw, on the graph, a line to show the path that **P** would follow assuming that air resistance only affects motion in the horizontal direction.

(2)

(e) Explain your answer to part **(d)**, including the reason why air resistance is negligible in the vertical direction.

_____

_____

_____

_____

_____

(2)

(Total 12 marks)