

DELTA SURGE

Kshetrij 2014

Delta Surge



WWW.KTJ.IN



IIT KHARAGPUR

1. The Problem Statement Requires:

- To build a RC electric-powered vehicle that should be able to move on both land and water and shoot at a given target. The participants need to make the vehicle complete the tasks provided in the Problem Statement with the minimum possible time.
- The details of the problem statement have been put up on our website www.ktj.in

2. Theory of Amphibious Vehicle (AV):

- **Lift:** If the weight of water displaced by the vehicle is more than the weight of vehicle, then it floats.
- **Thrust:** It is based on air jet principle. Air is pushed at high speeds by the propeller, which by Newton's third law, provides thrust to the boat.

- **Friction:** Wheels of the vehicle push ground below them backwards, which by Newton's third law, provides forward friction force to the vehicle while it is moving on land.
- **Navigation:** Control surfaces (rudder) are used to alter the path of the boat by thrust vectoring to produce lateral forces.

- **Impulse:** The vehicle needs to shoot at a given target using an impulsive mechanism. Using the impulse to project a pellet/ball at the target, is the most preferred mechanism for shooting.

3. Basic moments and forces acting on AV:

- **Horizontal Forces:**

1. Thrust Force(T)
2. Drag Force- sum of air drag and Surface Friction(D)
3. Friction Force(F) - result of backward push of wheels to the ground
4. Recoil Force (R)- After shooting

- **Vertical Forces:**

1. Weight(W)
2. Normal Reaction(N)

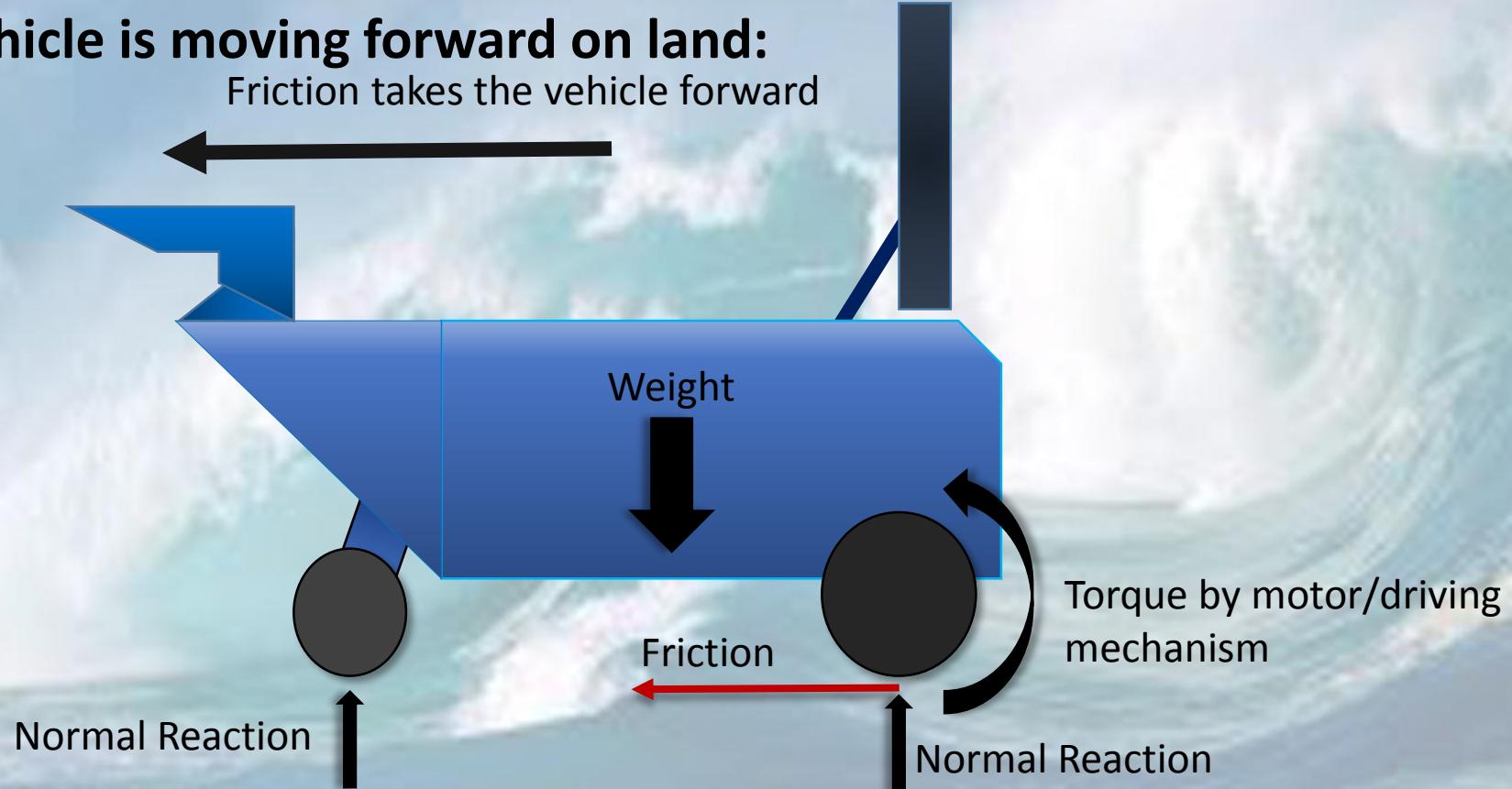
- **Moments:**

1. Torque generated by Thrust generating motor, Buoyant force
2. Torque generated by additional drag on wheels ,while in water
3. Torque generated by the recoil force created by shooting the target.

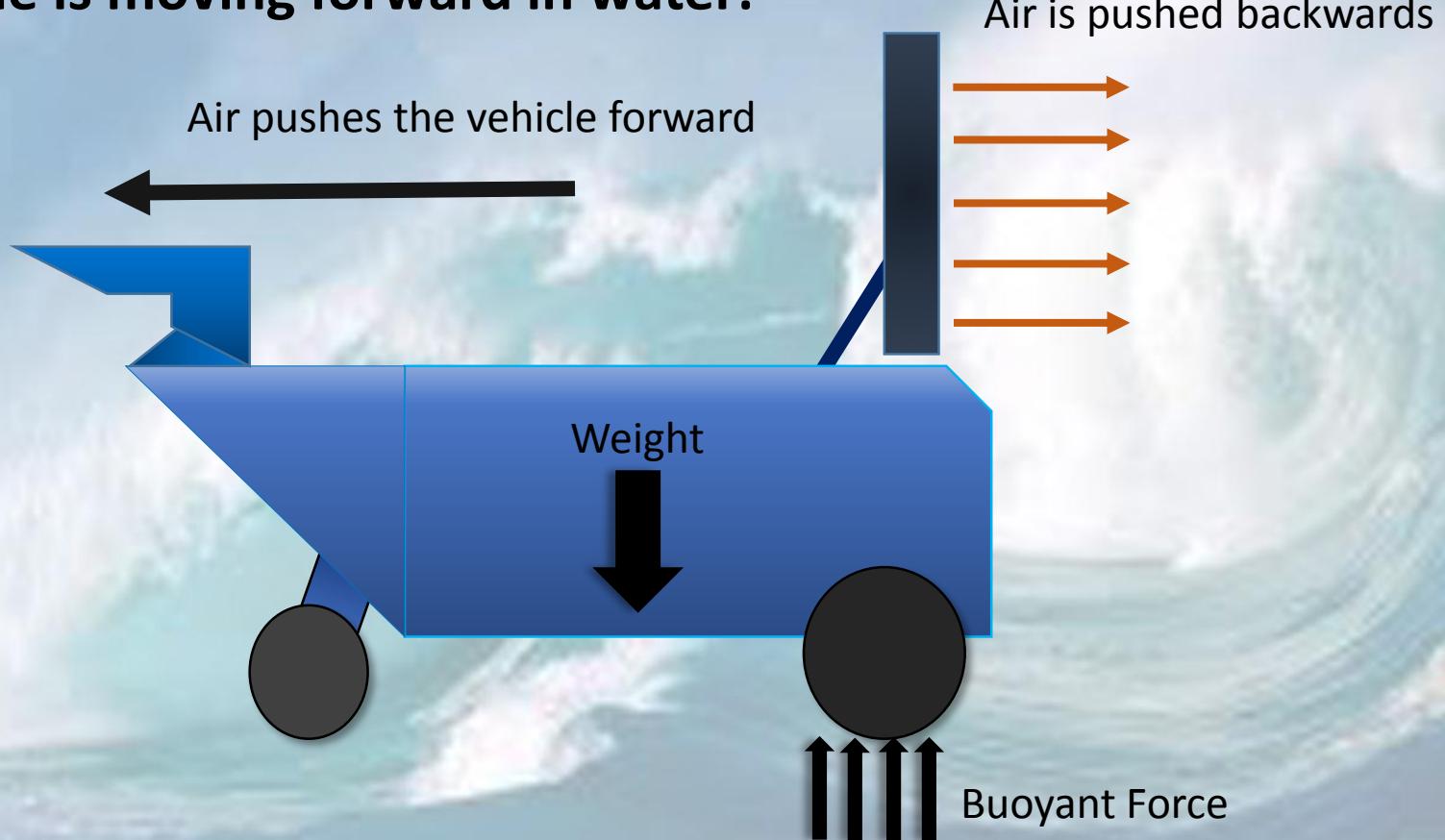
Basic forces acting on AV:

Vehicle is moving forward on land:

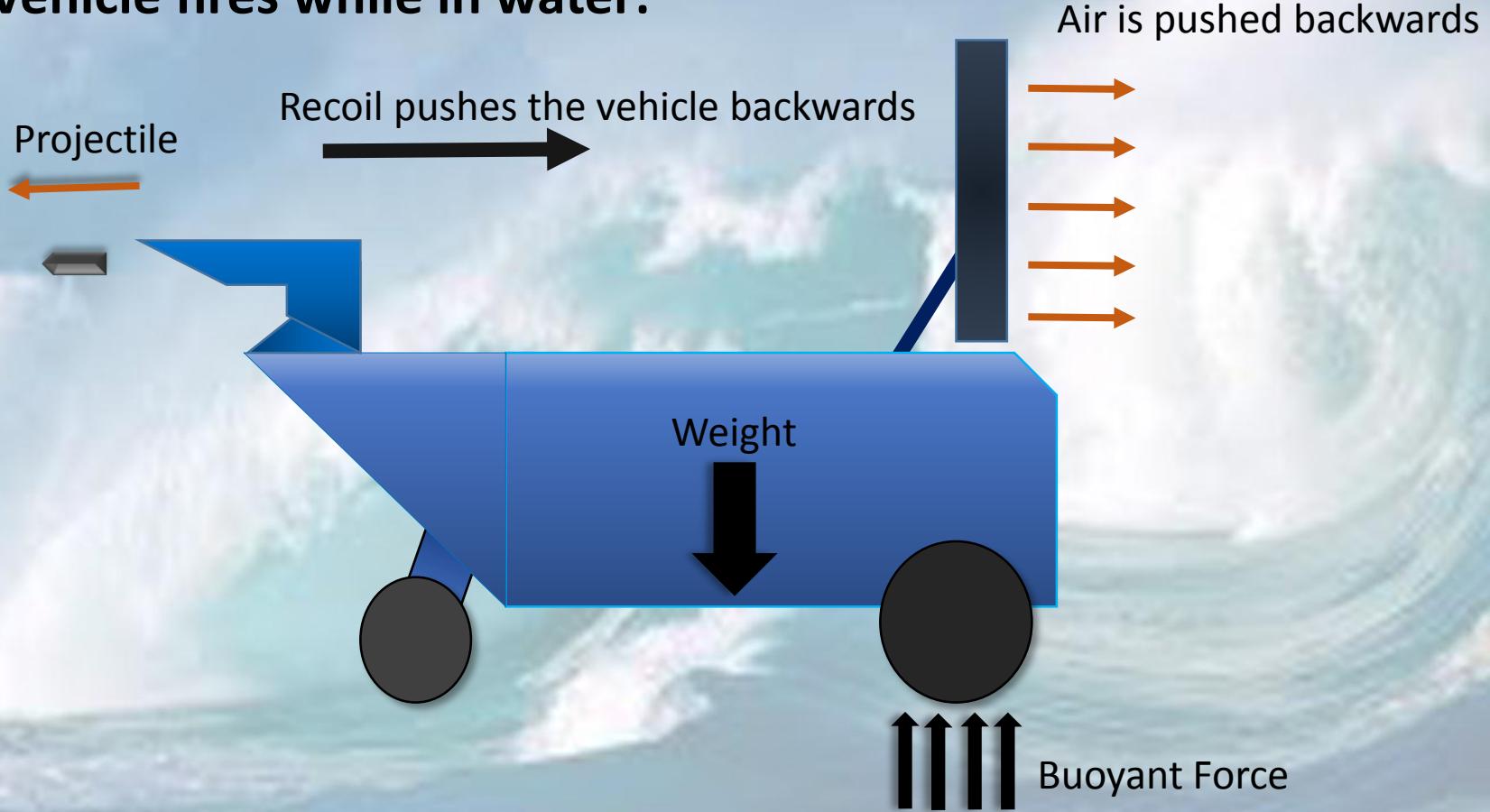
Friction takes the vehicle forward



Vehicle is moving forward in water:



Vehicle fires while in water:



Parts of AV (graphical)



This is only an approximate model and does not actually represent the actual model.

4. Parts of an AV:

- The Parts are listed below:
 - a) The Body
 - b) Locomotion(Motor + Wheels)
 - c) Thrust Generation (Motor + Propeller)
 - d) Control surfaces (Rudders)
 - e) Electronics to operate the motors and rudders (Electronic Speed Controllers + Servos + Transmitter + Receiver)
 - f) Power source (Batteries)
 - g) Shooting

a) The Body:

- The Body of the airboat can be made up of :
 - Styrofoam
 - Plastic Corrugated Sheets
 - Light Weight Wood (Preferably Balsa)

b) Locomotion:

- An AV can be driven using motor & wheel combination
- A wheel-system when rotated at required speed by sufficiently powered motor, pushes the ground backward and hence generating forward locomotion.

b)

1. Wheels:

A wide range of wheels is available in the market. You are free to use any according to your model. However it is advisable to use wheels with lesser diameter and thickness to reduce the drag while in water

2. Motor:

DC motors are best suited for this model, as they are robust and cheap. A wide range of DC motors with different RPM's is available in market. You are free to choose a DC motor of suitable RPM for your model.

c) Thrust Generation:

- An Airboat can be propelled using motor- propeller combinations.
- A propeller, when rotated at high speeds by a sufficiently powerful motor, creates an air-flow in the direction opposite to the heading, thus creating thrust.

1. Propeller:

A wide range of propellers are available in the market. You are free to choose any according to the requirement of your model. For example:

1. Carbon Fibre propellers: These propellers are highly durable and crash resistant. They are costly, but affordable.
2. Plastic propellers: These propellers tend to break easily on impact. They are cheap as compared to the Carbon Fibre ones.

2. Motors:

Two types of motors can be used:

1. Brushed
2. Brushless



Brushed



Brushless

- Brushed motors are more rugged, robust, cheaper and easier to use.
- Brushless motors are lighter, less prone to damage due to overheating, and cost more than the brushed ones.
- An electronic speed controller (esc) has to be used to control either of the motors

d) Control Surfaces (Rudders) :

The Rudder is the main control surface of an airboat which helps in deviating a body about its vertical axis. It is advisable to use two rudders for better control. The rudder deflection is controlled by servo.



Rudder

e) Electronics of AV:

- Electronic Speed Controller
- Electronic Motor
- Transmitter & Receiver
- Batteries
- Servo



f) Power Source :

- For a remote controlled airboat the most common power source used are Ni-Cd Battery and Lithium Polymer (Li-Po) battery.
- Li-Po batteries are necessary for brushless motors for high endurance.



g) Shooting

- The vehicle has to shoot a target using a projectile.
- Reloads are permitted only if automatic.
- The vehicle is required to stand at a distance from the target while shooting.
- The recoil force may throw the vehicle off balance, so preferably it should be heavier towards the bottom lowering the CoM.



5. Locomotion on land

A 3 wheel system or a 4 wheel system(or any other multi wheel system) can be used for this problem statement.

a) 3 wheel system:

In a 3 wheel system, the front wheel system is a single caster wheel and back wheel system consists of two wheels on the rear part of the AV driven by motor(s) attached to them.

b) 4 wheel system:

This system comprises of two wheels in the front and two in the back. It is also known as a skid steer system as the wheels in the front skid according to the motion of the back wheels which are attached to the motors. Usage of four wheels will increase the drag in the water.

6. Minimization of friction:

Friction minimization increases the acceleration and performance of the airboat. It can be minimized by using streamlined shapes and small cross sectional area.



7. Stability:

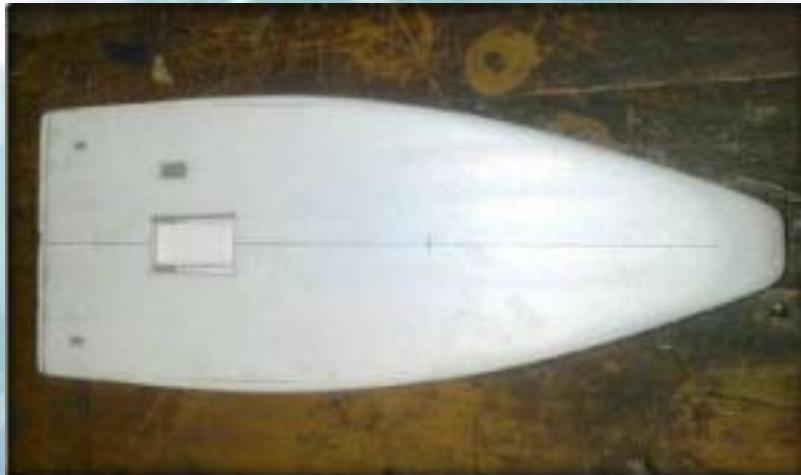
- For the stability of anybody the forces and torques acting on it must be balanced. In the case of an airboat, the following two things must be done for its stability:
 - The torque of the driving motor should be balanced (both about longitudinal and lateral axes). Torque about longitudinal axis can be balanced by trimming the rudder, and that about lateral axis can be balanced by making front part of the bottom surface slightly inclined.

- The shooting mechanism will generate a recoil force and the resulting torque will actually cause the vehicle to topple over in water. Necessary precautions like balancing flaps or heavier base should be incorporated into the vehicle.

8. Steps for construction:

a) Body shaping :

The body can be shaped according to your design. The size and weight are kept such that the nose of the boat stays in the air.



b) Mounting Mechanism :

Longitudinal strips of wood are placed on the body to mount the motors, ESC, battery, and receiver of the remote controller.

c) Mounting of Wheels:

Motor clamps are fixed on the base to mount the motors, and wheels are attached to the motors.



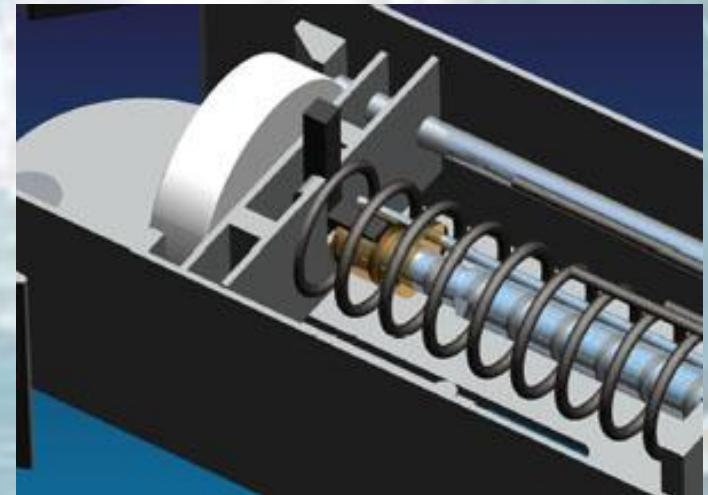
c) Servo And Rudder Attachment :

The rudders can be mounted as shown in figure but can also be attached at any other part of the vehicle. Servo is placed in a suitable place so that it can be easily attached to the rudder.



9. The Shooting Mechanism

- The bot should consist of a shooting pad and a spring attached to it. A motor/rack and pinion system should be made to draw the pad backwards after firing.



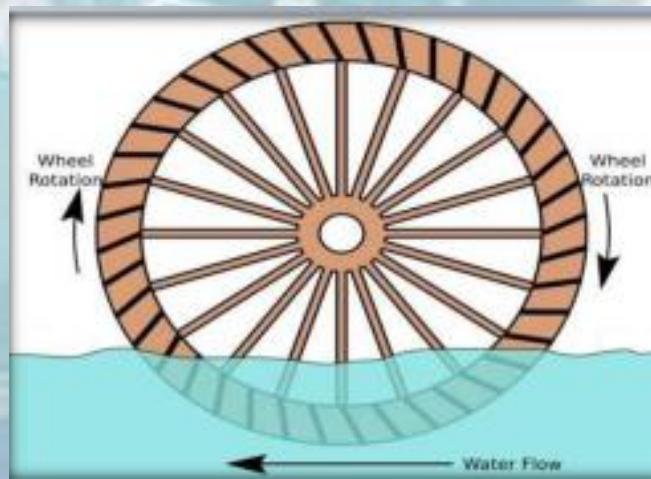
- The projectile should be placed in front of the pad and with the help of a small motor or some other trigger, the wound back pad should be released hitting the ball to the target.
- The rack and pinion will be used to pull back the pad after shooting.

10. The Final Model: (approx.)



11. Other Possible Mechanism:

The AV can be made by use of wheels which are capable of producing propulsion in water (as shown in the pic.). In this mechanism the wheels act as motion actuators both on land as well as water. The rotation of the wheel in the water produces a forward thrust enabling the boat to move ahead.



- The wheel used is a called Paddled Wheel which has plates placed to push the water adequately producing required thrust to navigate in the water.
- The wheel has slots which push the water back and the boundary rims are completely circular allowing navigation on land as well.

Shooting Mechanism (Alternate):

- **Motor and Flipper**

A flipper mechanism attached to a motor can spin at a considerable speed. A track that leads the projectile into the flipper ensures that it gets hit by the flipper sending it into the necessary trajectory, and hit the target.

12. Points to ensure:

- The torque produced by the motors should be sufficient to produce enough forward force in water. It is observed that the motors in water are not able to provide the rated rpm in water due to the increased retarding force of drag which the motor has to counter in order to continue motion in water.

- The details of the problem statement have been uploaded on the Kshitij '14 website at <http://ktj.in/events/deltasurge>
- Queries regarding Delta Surge will be answered through the forum.
- For further queries contact Event Head.

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