

Internship at Nilkamal Pvt Ltd

DESIGNING AN AUDITORIUM CHAIR

Industrial Design Project I
IDC, IIT Bombay

Minu
176130011



Industrial Design Centre
Indian Institute of Technology, Bombay



Nilkamal Limited



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Dated: 7th July' 2018

The Director,
IIT Main Gate Road,
Powai,
Mumbai - 400076
Maharashtra.

Sub: Internship with Nilkamal Ltd.

Dear Sir / Madam,

This is to certify that Ms. Minu has successfully completed her Summer Internship in Design department. She has done market study and concept generation of new designs of Auditorium Chair. Her internship period was from the period 7th May 2018 to 30th June 2018.

During her internship we found her to be very industrious and sincere and she has made positive contributions. We wish her all the very best in her future endeavors.

For Nilkamal Ltd.

A.K Tyagi
Senior Manager – Human Resources

INTRODUCTION

Nilkamal Limited is a plastic products manufacturer based in Mumbai, India. It is the world's largest manufacturer of moulded furniture and Asia's largest processor of plastic moulded products. Their product range consists mainly of custom plastic mouldings, plastic furniture, crates and containers.

- In 2011, the company also began production of mattresses.
- The Company has 8 large manufacturing plants in India:
- North - Samba (Jammu & Kashmir) and Greater Noida (Uttar Pradesh)
- East - Barjora (West Bengal)
- West - Sinnar, Nashik (Maharashtra) and Silvassa (Union Territory of Dadra & Nagar Haveli) (2 plants)
- South - Pondicherry (Union Territory) and Hosur (Tamilnadu)

The Company has advanced machinery in Injection Moulding, Rotational Moulding, Vacuum Forming, Polyurethane Injection (of insulation) and capabilities for Blow Moulding.

PROJECT OBJECTIVE

The objective of the project was to design an Auditorium Chair.

It must have a tablet for writing purpose, it should have tip-up or slide in-out mechanism for the seat. The design should use standard dimensions provided by the Nilkamal. The form of the seat should look comfortable and easy to use. Design the chair keeping in mind that it should be easy to assemble and maintenance friendly.

I was asked to design the upholstered seat and back also suggest the form of the injection molded plastic covering.

PROCESS

RESEARCH, ANALYSIS AND FINDINGS

The study on various attributes associated with auditorium chair.

FLOOR

Study and understand the role of floor and its design for the auditorium seating. Flat or less steeply sloped floor allows people to have more room for extend their knees and legs.

There should be provision of free spacing between the seating for the comfortable sitting position. As floor slope is increased the ‘free space’ diminishes. An example would be a 12” high riser and 32” wide row spacing. Here, it becomes necessary to consider increasing the row spacing to provide more leg room.

For good visibility and listening conditions, successive rows of seats has to be raised over the preceding ones with the result that the floor level raises towards the rear.

Each listener should be elevated with respect to the person immediately in front of him so that the listener’s head is about 6 inches above the path of sound which would pass over the head of the person in front of him. With seat staggering it is possible to reduce this height to 8cm.

As an empirical rule the angle of elevation of the inclined floor in an auditorium should not be less than 8 degrees

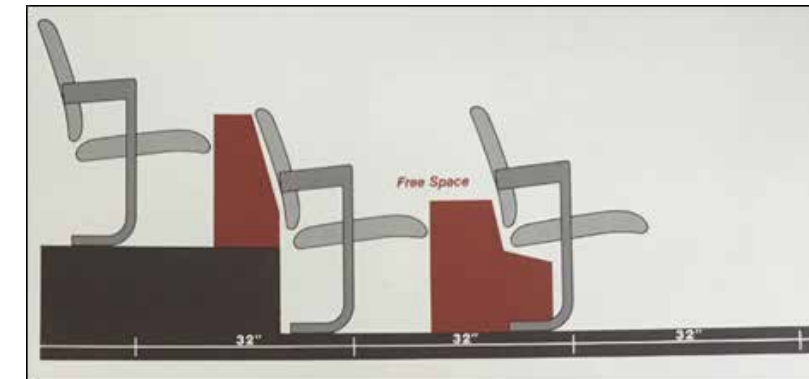


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STAGGERED SEATING

For best visibility no person should sit exactly in front of any other person.

Staggering is accomplished by the non-uniform placement of seats varying width in succeeding rows.

Odd – Even Tapered: Pick a chair size, and increase the chair count by one in successive rows. Obviously, this offers limitations on chair counts.

Sawtooth Stagger: Simply shift alternate rows by a half chair total, or shift successive rows one-quarter chair each way.

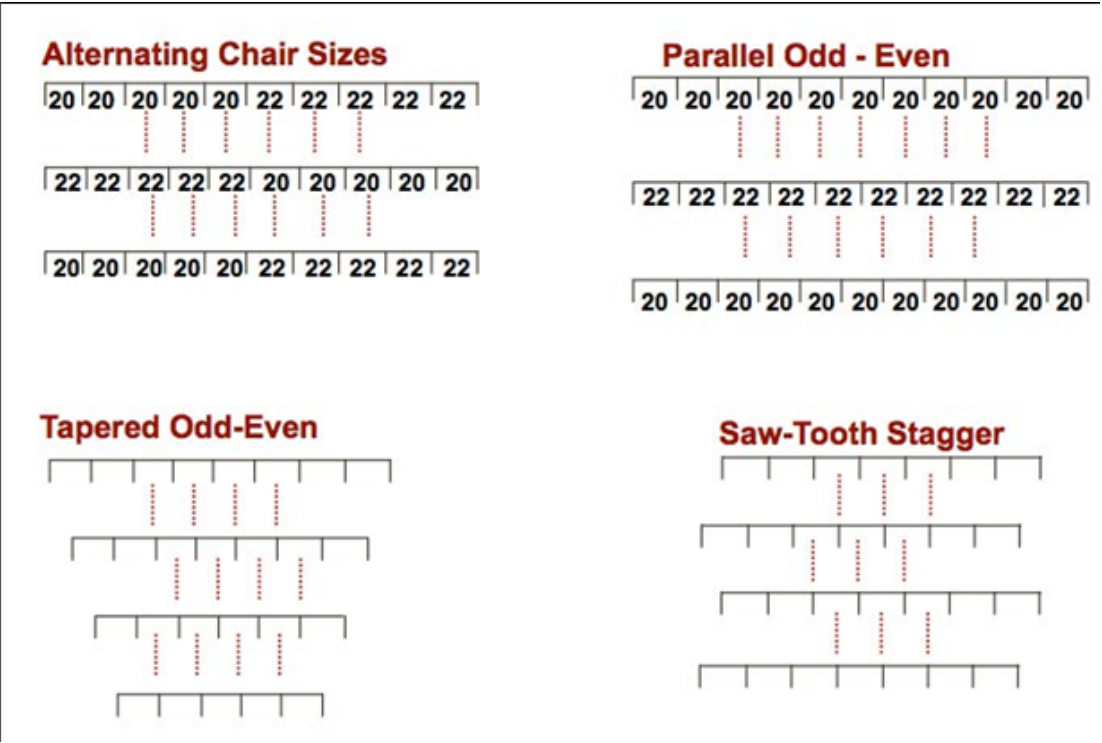


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MEASURING METHODOLOGY FOR A CHAIR

A - Total height

For products fitted with a gaslift – it is measured with gaslift's minimum and maximum extension.

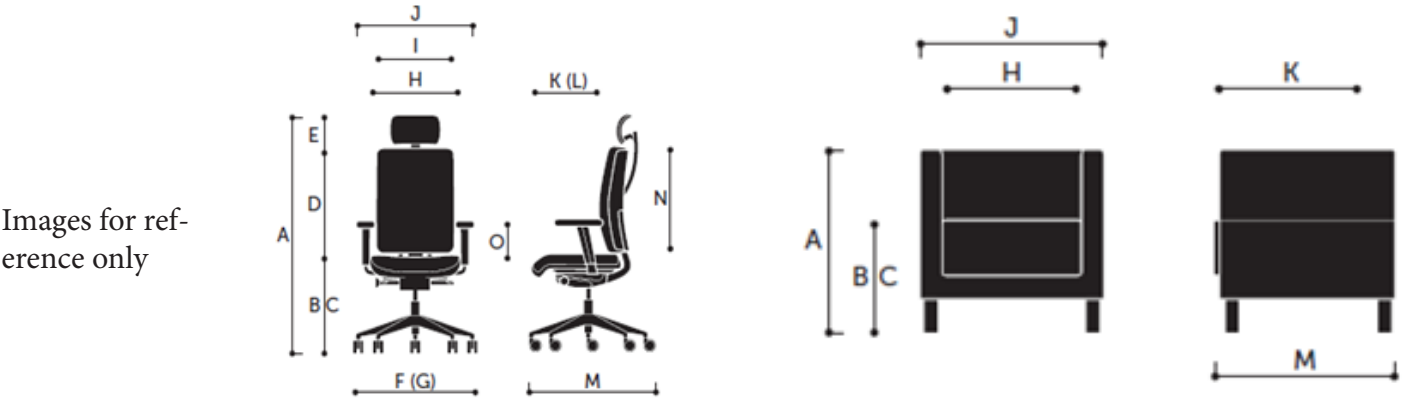
For products fitted with an additional backrest and headrest height adjustment – it is measured in both minimum and maximum positions of the backrest, headrest and gaslift.

B - Seat height

Measured at the highest point of the seat. For products fitted with a gaslift – it is measured with absorber's minimum and maximum extension.

C - Seat height with the burden

Seat measured according to EN standards (with seat burden). For products fitted with a gaslift – it is measured with galift's minimum and maximum extension.



Images for reference only

D – Backrest height

Measured from the seat to the backrest upper edge. For products with adjustable backrest height – it is measured in the minimum and maximum position.

E - Headrest height

Measured from the backrest upper edge to the headrest upper edge. The headrest adjusted in maximum vertical position in relation to the upper and lower edge of the headrest. Measured in the headrest's minimum and maximum position.

H - Seat width
Measured at the uttermost points of the seat.

I - Backrest width
Measured at the uttermost points of the backrest.

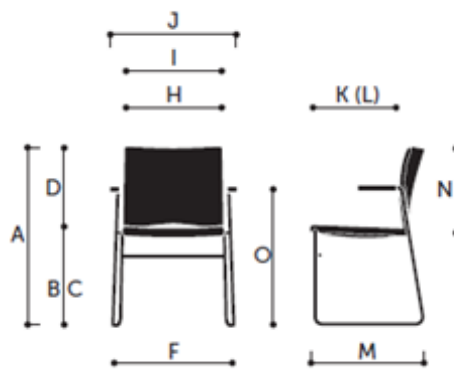


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J - Total width
Measured at the uttermost points. For products fitted with adjustable armrests – it is measured with the armrests slid apart to maximum.
For products fitted with armrests with adjustable pads – it is measured with the pads slid apart to maximum.

K - Seat depth
Measuring the distance between the uttermost point on the seat and the point it touches the backrest (the contact point is determined with a level positioned vertically to the backrest by projecting the S point from the backrest onto the seat) (1). For some shell chairs, where there is no distinct border-line between the seat and the backrest, the depth is measured on the bend halfway between the seat and the backrest (2).
For products with additional adjustable seat depth – it is measured with minimum and maximum slide.

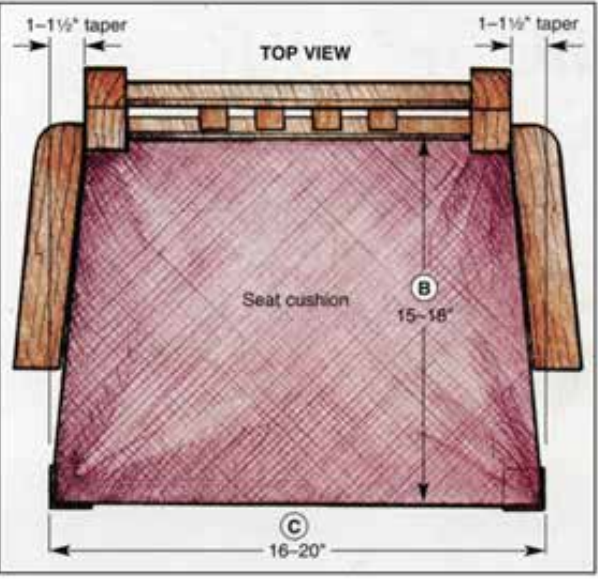
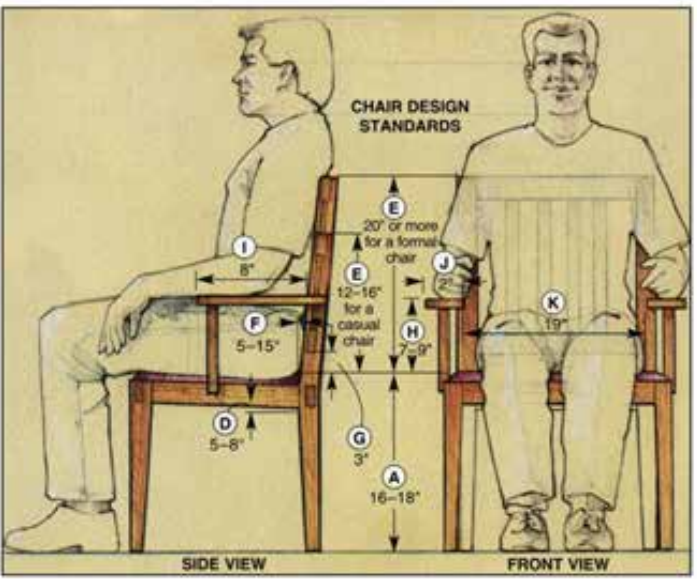
N - Backrest (element) length
Measured at the uttermost points of the backrest.

O - Armrest height
For swivel armchairs and chairs – it is measured from the seat surface to the armrest upper edge. For armrests with adjustable height – it is measured in the minimum and maximum position. For conference chairs – it is measured from the floor to the armrest upper edge.

STANDARD CHAIR DIMENSIONS

The following dimensions apply to chairs designed for average-sized adults sitting in an upright or alert posture.

- Seat width 16"-20"
- Seat depth 15"-18"
- Seat height from floor 16"-18"
- Slope of seat front to rear 5° to 8° (3/4" to 1" drop)
- Armrest height above seat 7"-9"
- Arm rest length (full arm rest) 8" minimum
- Armrest width 2" average
- Set back of arm rest from front 2"-3"
- Seat back height 12"-16" above seat (casual) 20" and more (formal)
- Seat back recline angle 0°-5° (formal); 10°-15° (casual)



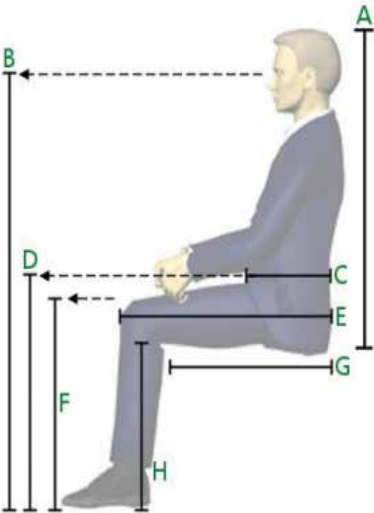
ERGONOMICS

- Chairs should have a seat pan with a waterfall front (one that curves down) that prevents the seat from catching you behind the knees.
- The seat pan should be long enough to provide you with comfortable support for at least three-quarters of the length of the thigh.
- The armrests should be designed to be broad, contoured, cushioned, and comfortable.
- Armrests should be padded and engage the fleshy part of the forearm. They should not engage the bony parts of the elbow where sensitive ulnar nerve is close to the surface so a gap of approximately 4" between the armrest and seat back is recommended.
- Armrests should be at least 17.2" apart to exceed thigh breadth of 95th percentile females.
- Seat height should be adjusted to support a knee angle of 90-degrees to prevent leg swelling.
- Fixed Height - should be about 17" (43cm). This is a compromise. A chair that is too high leads to increased pressure at the popliteal fold (underside of knees), decreasing blood circulation and increasing pressure on the nerve. A chair that is too low increases weight on the ischial tuberosity.
- Minimum Height - should be 15" (38cm) which designs to the 5th percentile of women with 1" heels.
- Seat Cushioning - recommended thickness at 1.5-2". Cushion should be firmer in back and thicker while less firm and thinner at front.
- A soft chair may be comfortable at first, but as the body sinks blood circulation lowers, skin temperature rises in affected areas, and compression under thighs increases. These factors combine to increase discomfort.
- Seat Width - around 20 - 22" to accommodate clothed persons.

ANTHROPOMETRIC DATA

Some of the relevant dimensions of the human body that are standard for Indian Human Body were documented. The dimensions are taken from the book “Indian anthropometric dimensions for ergonomic design practice” by Debkumar Chakrabarti.

Measurement	Letter	Female 5th – 95th%	Male 5th – 95th%	Overall Range 5th – 95th%
Sitting Height	A	31.3" – 35.8"	33.6" – 38.3"	31.3" – 38.3"
Sitting Eye Height	B	42.6" – 48.8"	46.3" – 52.6"	42.6" – 52.6"
Waist Depth	C	7.3" – 10.7"	7.8" – 11.4"	7.3" – 11.4"
Thigh Clearance	D	21.0" – 24.5"	23.0" – 26.8"	21.0" – 26.8"
Buttock-to-Knee	E	21.3" – 25.2"	22.4" – 26.3"	21.3 – 26.3"
Knee Height	F	19.8" – 23.2"	21.4" – 25.0"	19.8" – 28.0"
Seat Length/Depth	G	16.9" – 20.4"	17.7" – 21.1"	16.9" – 21.1"
Popliteal Height	H	15.0" – 18.1"	16.7" – 19.9"	15.0" – 19.9"
Seat Width	Not Shown	14.5" – 18.0"	13.9" – 17.2"	13.9" – 18.0"



measurement of an adult human

Anthropometric data for a person in sitting position. The above table can be used for designing chairs.

The Indian adult dimensions considered for the 95th Percentile of the population are listed here which are relevant to the design of chair:

Shoulder Height:
Male: 634 (24.9")
Female: 586(23.07")

Knee Height:
Male: 567 (22.32")
Female: 520 (20.47")

Seating Height:
Male: 893 (31.69")
Female: 731 (28.77")

Eye Height:
Male: 893 (35.15")
Female: 809 (31.85")

Popliteal Height:
Male: 471 (18.54")
Female: 441 (17.36")

Knee to knee (relaxed):
Male: 535 (21.06")
Female: 410 (16.14")

Buttock to knee length:
Male: 615 (24.21")
Female: 585 (23.03")

Waist Height:
Male: 221 (8.70")
Female: 260 (10.73")

Lower Lumbar:
Male: 156 (6.49")
Female: 189 (7.44")

Elbow rest height:
Male: 270 (10.62")
Female: 265 (10.43")

Hip Breath:
Male: 405 (15.94")
Female: 429 (16.88")

Upper Lumbar:
Male: 354 (13.93")
Female: 346 (13.62")

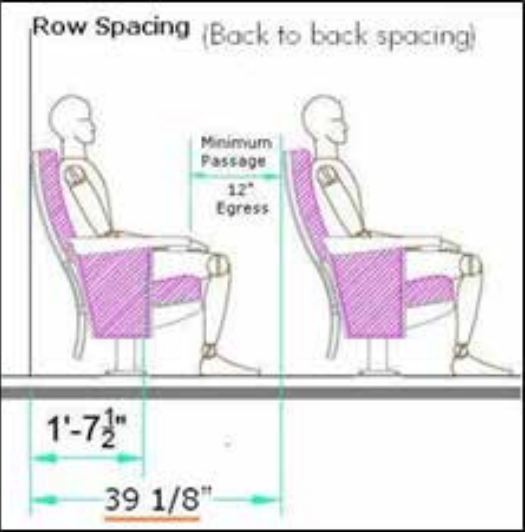
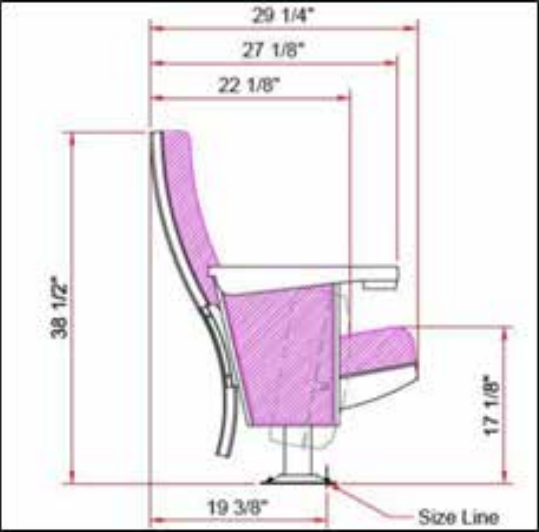
Buttock to Popliteal length:
Male: 512 (20.15")
Female: 494 (19.44")

Forearm - Forearm breath:
Male: 489 (19.25")
Female: 435 (17.12")

Tip to Shoulder blade:
Male: 476 (18.74")
Female: 419 (16.49")

COMPARATIVE STUDY OF DIMENSIONS OF HUMAN BODY AND EXISTING SEATS

Human body measurement	Anthropometric measurement	Alden Theater Seat	Godrej glamour chair	Godrej Jupiter HB chair	Chair measurement
Sitting height from ground(A+H)	46.3” - 58.2”	38.50”	42.12”	40.12”	Back Height
Buttock to knee (E)	21.3” - 26.3”	29.25”	25”	27.55”	Width of chair
Popliteal height (H)	15.0” - 19.9”	17.62”	16.9”	18.30”	Seat height from ground



MATERIALS

The study of various material that are used in the industries for the development of an auditorium seat was done mostly online. Understanding the use and features of the materials, the properties that were essential for the seating and resisting fire. The materials that could be used as alternative and could be efficient to reduce the cost were read and studied. The following list shows the materials that are widely used in the manufacturing different parts of an auditorium chair by the current industries:

- Seat cushion:** cold molded foam (PU)
- Seat cover:** Polyester , leather, fabric, eco-leather, etc
should be flame- retardant, non-deformable
- Armrest:** Hardwood, plywood, Polypropylene, PU
- End option (below armrest):** PP, wood, veneer, fully upholstered
- Legs:** polished aluminium, steel (12-14 gauge) structure, cast iron
metal structure is painted with non-scratched epoxy polyester powder

STUDY OF AUDITORIUM CHAIRS

IDC AUDITORIUM CHAIRS

Some of the students in IDC felt there were some issues with the design of the IDC auditorium chair. The chair seems to be a minimal design with proper ergonomics. It is red colored upholstered seat with long chain mounting. It also has a simple mechanism with the tablet provided along as writing surface.

The problems that some students felt was associated with the seat are as follows:

- Too long chains – problem with arrangement
- Each stair has 3 rows of chairs
- Footrest behind the chair, stamp on the foot rest the chair vibrates a lot
- Service is difficult a long chairs
- Has attached table top – simple and easy to use
- Permanent contact – only back seat moves Forward and Backward
- Seat are not tip up
- They are fixed in one position
- Less space between the chairs to move for other people
- The headrest is absent so becomes uncomfortable after long seating
- 6 connected seats with 3 stands
- Each stand uses 2 bolts to mount the chairs to the floor



IDC auditorium chairs

STUDY OF AUDITORIUM CHAIRS



IITB VMCC lecture hall chairs

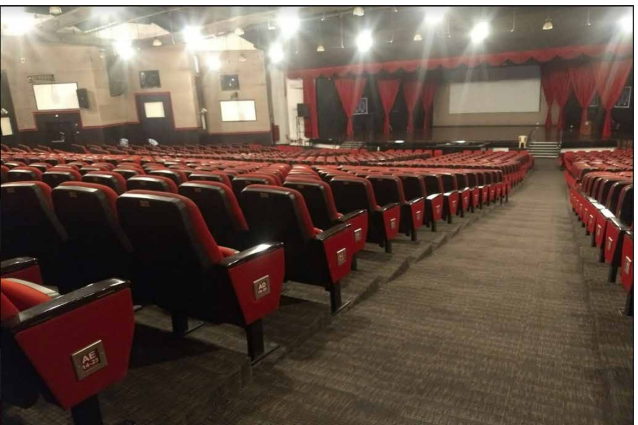
IITB VMCC LECTURE HALL CHAIRS

A study of the Lecture hall seat was also included in-order to understand the joints and tip up mechanism. The seats were simple and minimal with only wooded veneer and metal use. The seats of three were attached together.

Some key points associated with the seat are as follows:

- Each stair has one row of chairs
- 4 legs for 3 chairs
- Each stand uses 2 bolts to mount the chairs to the ground while for the table it had 3 bolts per leg
- Simple tip up mechanism (fluent movement)
- Has separate table
- Metal and wood only – not upholstered
- Comfortable for short time period
- Lack of headrest
- No arm rest

STUDY OF AUDITORIUM CHAIRS



IITB convocation hall chairs

IITB CONVOCATION HALL CHAIRS

A detailed study of the IITB convocation hall chairs were done. The objective was to collect the dimensions of the existing chair and apply a comparative study with the dimensions of the existing chairs in market and human dimensions as well. The design was similar to most of the auditorium chairs that are in the market. It was comfortable and easy to use.

Some key points associated with the seat are as follows:

- 8 chairs in one common frame
- A slope in hall with risers for each row
- Side support legs
- Each stand uses 2 bolts
- Simple tip up mechanism (fluent movement)
- Storage for the tablet when not in use inside armrest (unlike the tablets in IDC auditorium)
- Metal, wood and cushion
- Comfortable
- Armrest with wooden top
- Simple hinge mechanism (door like) for tablet
- Tip- up weight balance for seat

IITB CONVOCAATION HALL CHAIRS - DIMENSIONS

Total height of the chair from ground: 1000 (39.37in)

Armrest length: 400 (15.74in)

Armrest width: 85 (3.34in)

Armrest height (from ground): (265+380= 645 (25.39in))

Back seat height (from seat): 670 (26.37in)

Back seat thickness: 120 (4.72in)

Back seat width: 520 (20.47in)

Seat thickness: 120 (4.72in)

Seat height (from ground): 420 (16.53in)

Seat length (from back seat): 480 (18.89in)

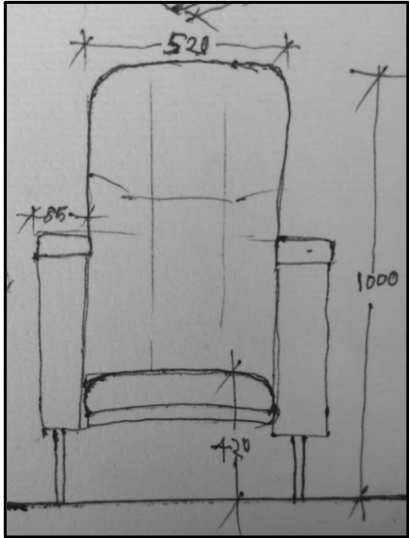
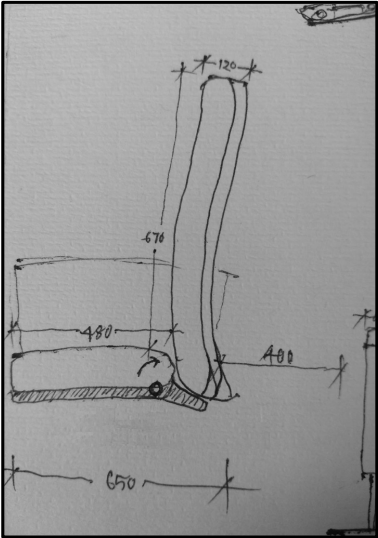
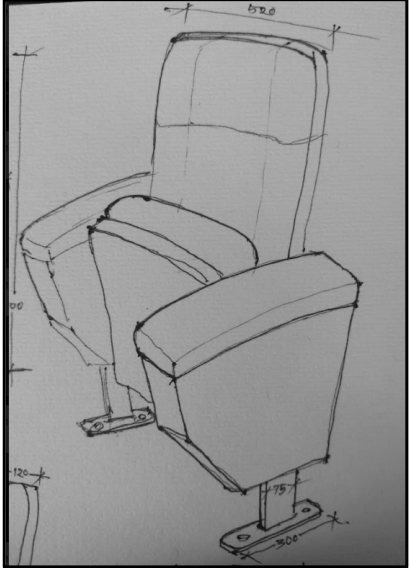
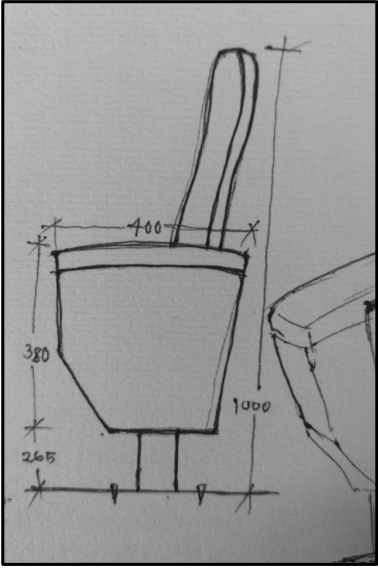
Width of chair (seat open): 650 (25.59in)

Metal stand length (from ground): 265 (10.43in)

Stanchions width: 75 (2.95in)

Distance between two seats (open seats): 400 (15.74in)

Seat riser: 100 (3.93in)



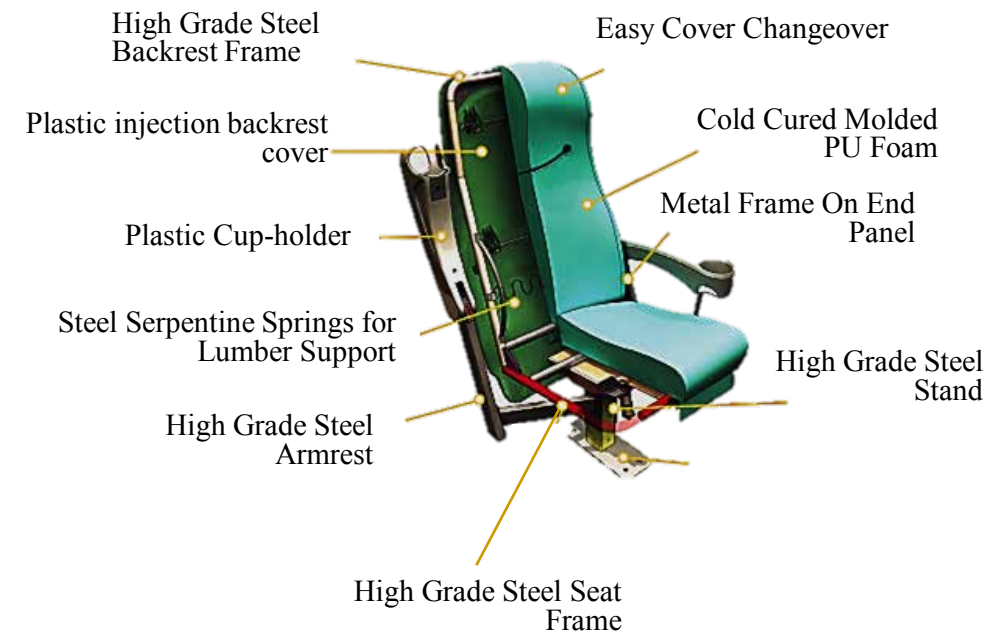
IITB convocation hall chairs-dimensions

INSIGHTS AND OBSERVATIONS

Some of the observations made during the study and derived insights

- Most companies are moving towards contemporary design and minimal design.
- Thinner padding which makes the product look light and requires less material
- Addition of charging plug points
- Easy to clean
- Easy maintenance
- Minimal parts creates it long lasting and durable
- Two legs or shared legs are more durable than centre base
- Old design - Deep curved backs so tight row spaces could be used
- Modern design has crescent backs
- Modern chair designs use deep padded backs and sloped stanchions- usually made of cast aluminium or steel.
- The crown height of the seat has been lifted to reflect the increase in average height – which adds to head rest as well
- Addition of veneer to the back- strength, aesthetic, durability
- Simple mechanisms like tip-up
- Double legged and single legged study

UNDERSTANDING CONSTRUCTION



In-order to start with a design or ideation it was important to understand the construction details of upholstered chair. Various videos and images that described the construction details were considered. Though the requirement was to come up with the form and appearance of the seat, the internal details plays vital role to decide the form. For example the upholstery done with too many curvatures and fixed shape may require different techniques and material to accomplish that, they may be fixed with wires pulled from behind or there and be use of rods to hold it. These details also play role to cut the cost for material as well as labor.

The fixing of arm rest and connecting the seat base and back seat was already discussed by the company. The chairs are designed individually with easy to assemble parts, later seats are assembled together with arm rest as a connector between two chairs. This also reduces transportation cost.

Steel serpentine Springs are used for Lumber support, the seat and back seat pan are made of plastic and they are injection molded. A high grade steel frame structure is covered with cold molded polyurethane foam on the front, while the rear side has plastic covers. The base is high gauge steel anchor plate which is bolted to the ground using bolting process.

KEY FINDINGS

At the end of the research and analysis I was able to come up with some common findings that were in most of the designs that are already existing. The process not only helped to jot the materials in the industry used for the manufacturing of the chair but it also shows that vastly these materials and methods has not been changed for long time. One can find opportunities to rework on the design with upcoming materials and technology. Here is a small compilation of the finding by the end of the process of research and analysis.

Seat back/cushion

- curvature
- lumbar support
- double curvature (may or may not be)
- veneer
- padding (cushioning) - polyurethane
- 'S' shaped (for ergonomics)
- color - to venue's tone
- fire-retardant

Seat fixing to ground

- hidden, expandable metal studs
- nut bolt
- a riser on there on which

Tip-up mechanism

- gravity based is more reliable than spring based
- counter weight

Seat back/cushion

- die-casting aluminium stanchion support
- wooden base
- strong steel structured support
- slopped (as per modern design)
- center base or 2 legged based(each on both side)

Seat Pan

- wooden, plastic, steel, plywood
- to be covered with upholster or simply a seat

Arm rest

- may or may not be adjustable
- made of ABS, Hardwood, plywood, PU
- may/may not have wooden cap, upholstered/cushioned

Accessories

- writing tablet - foldable - door hinge mechanism

SOME SUGGESTED AREAS OF IMPORVEMENT

Some of the insights found suggest that most companies are moving towards contemporary design and minimal design. They rely on thinner padding which makes the product look light and requires less material. An opportunity to provide accessories like addition of charging plug points is not getting popular.

Minimal design makes a chair long lasting and durable as it makes easy to maintain the product. Two legs or shared legs are more durable than center base, thought with improved material use center base are even getting popular in modern designs.

While old design would make deep curved backs so tight row spaces could be used, modern design has crescent backs and modern chair designs use deep padded backs and sloped stanchions- usually made of cast aluminium or steel.

The crown height of the seat has been lifted to reflect the increase in average height – which adds to head rest as well.

A chair which is ergonomic to one person might not be equally ergonomic to some other person.

Some of the issues that can be addressed in a chair:

- provision of seat depth adjustment according to user's requirement
- armrest adjustability (height)
- tablet height adjustable
- grooves to allow to hold the stuff on the tablet from slipping off
- adjustable lumbar back support
- adjustable neck support
- provision of charging ports or sockets

DESIGN BRIEF

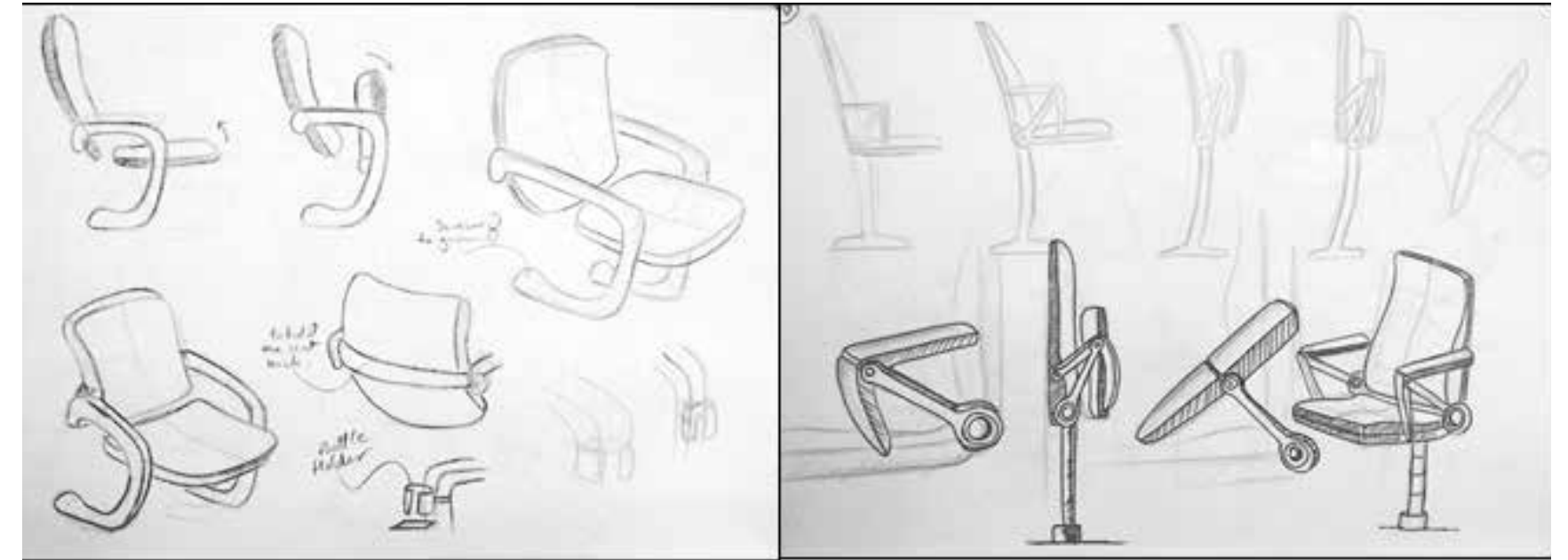
The idea was to design an auditorium chair that provides comfort to the user and was ergonomic to use. The design should have an additional writing surface with grooves to allow to hold the stuff on it from slipping off and provision of charging ports or sockets.

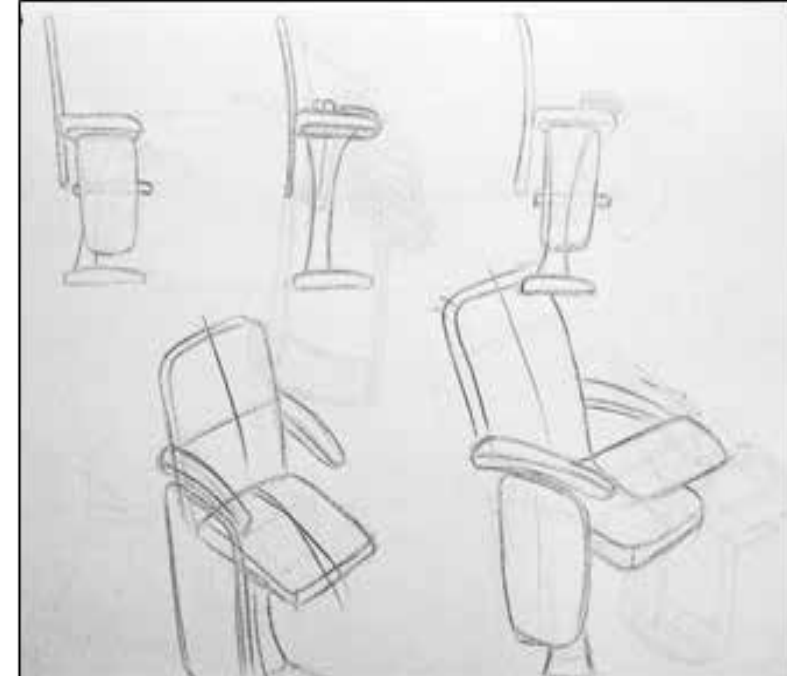
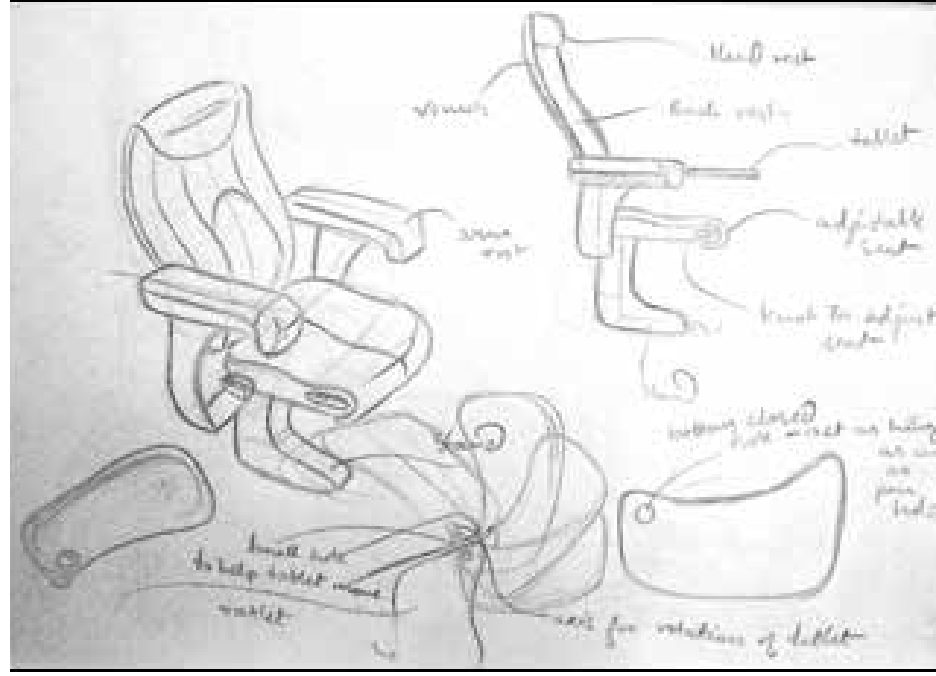
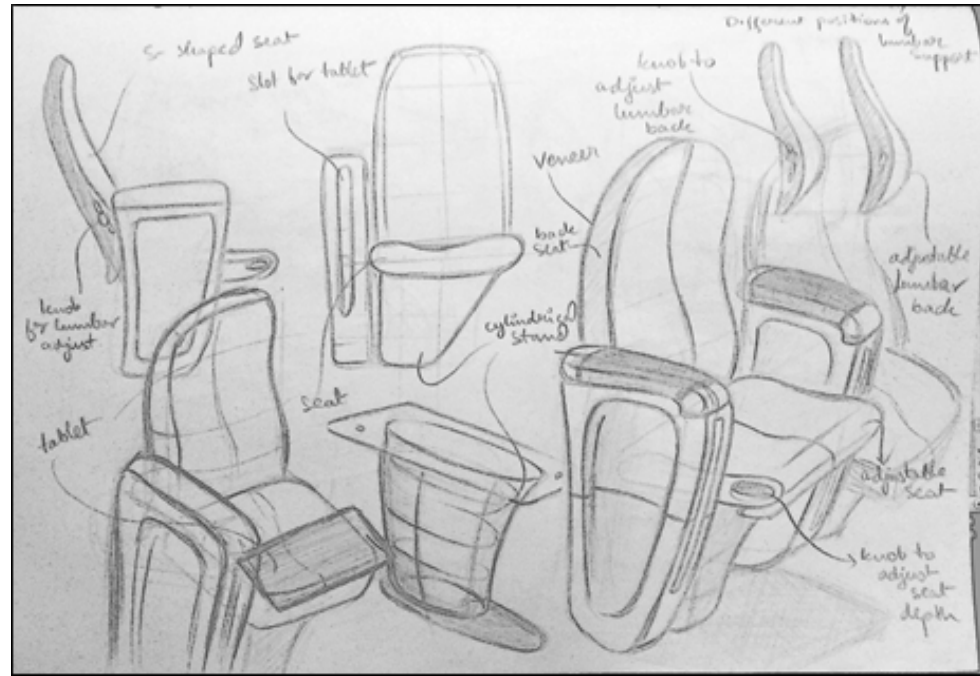
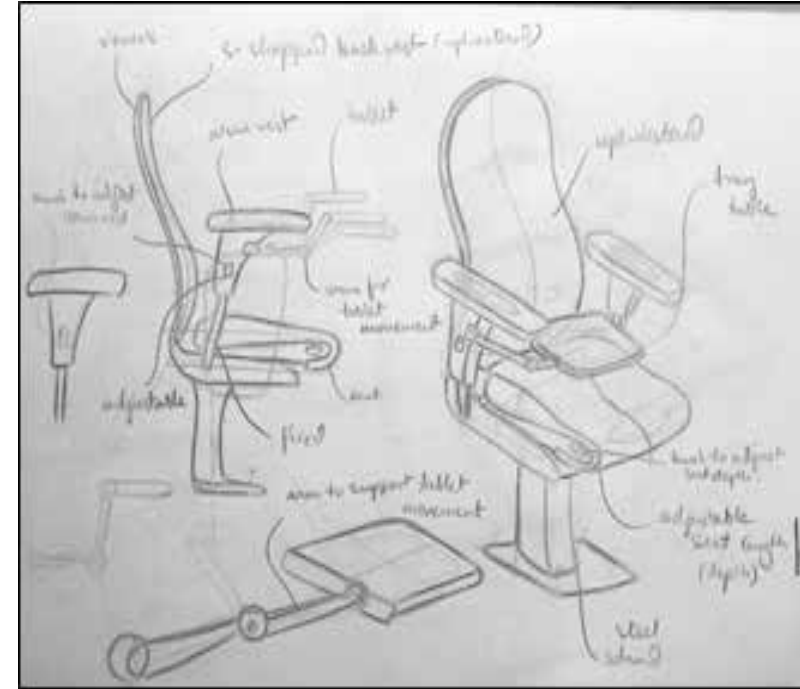
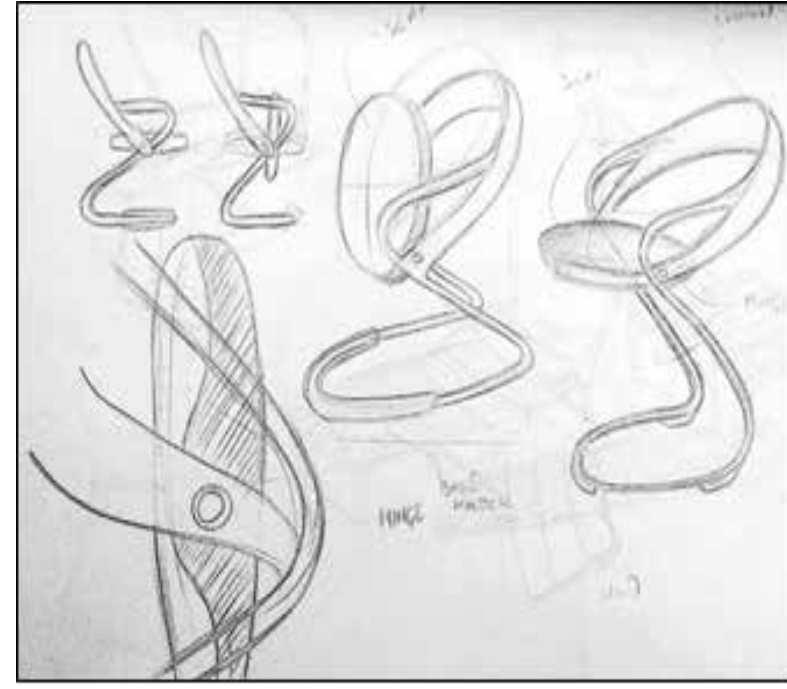
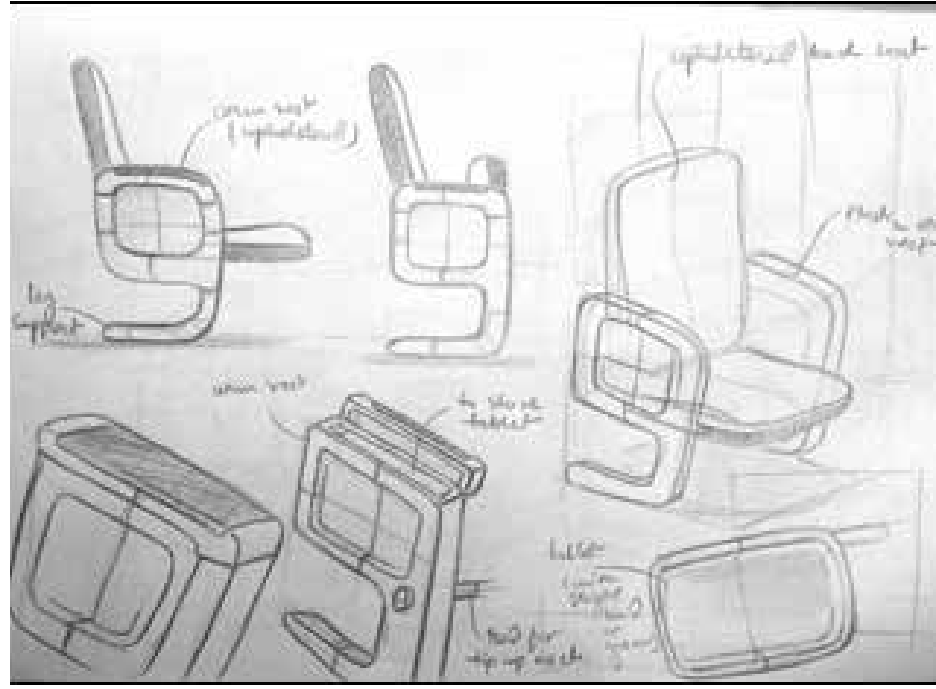
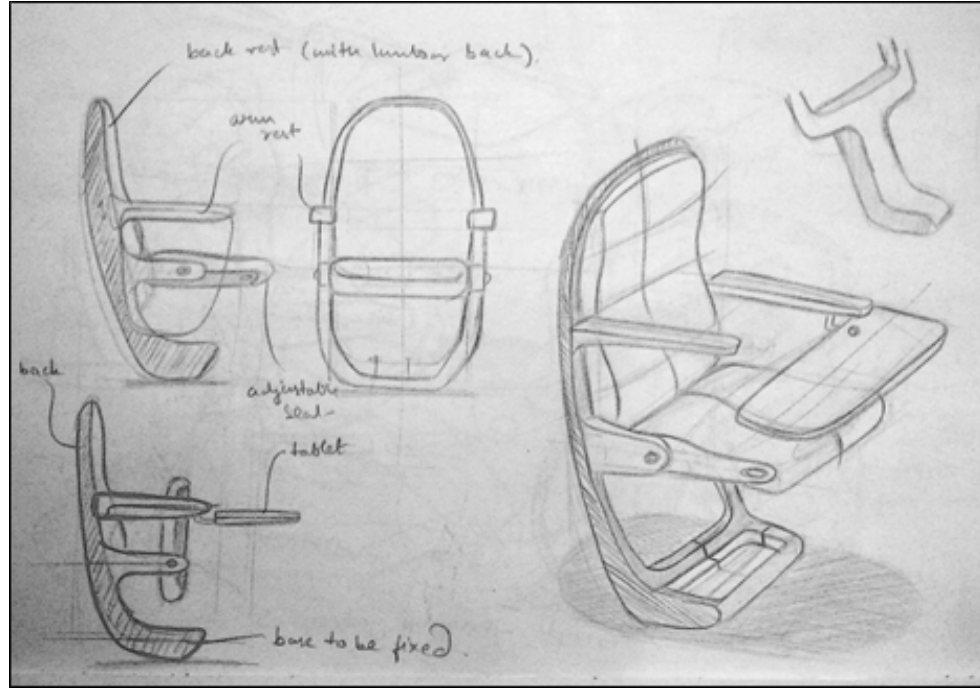
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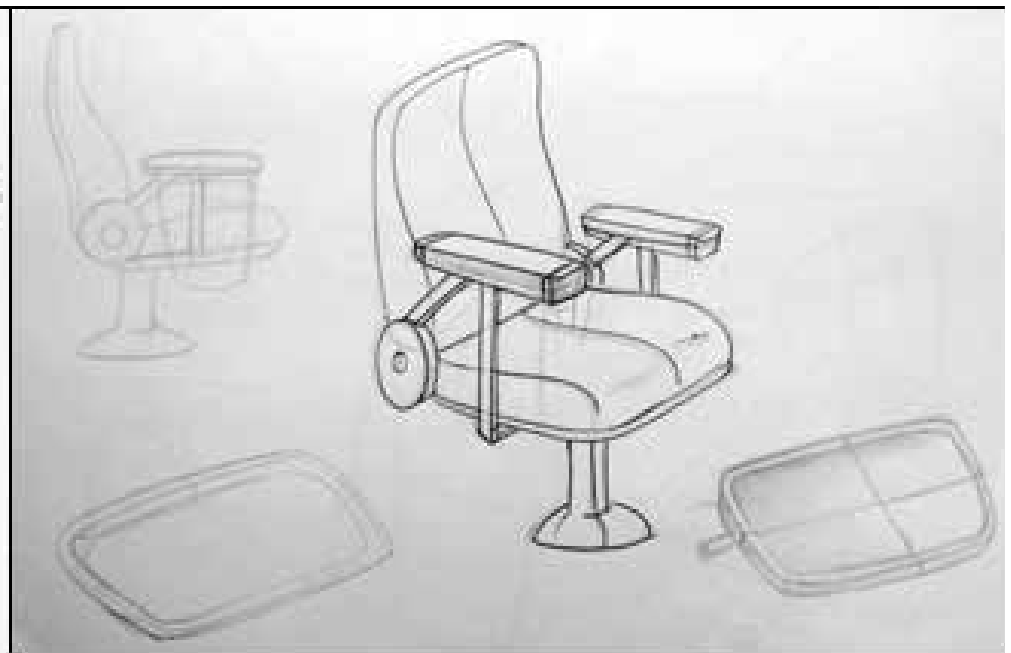
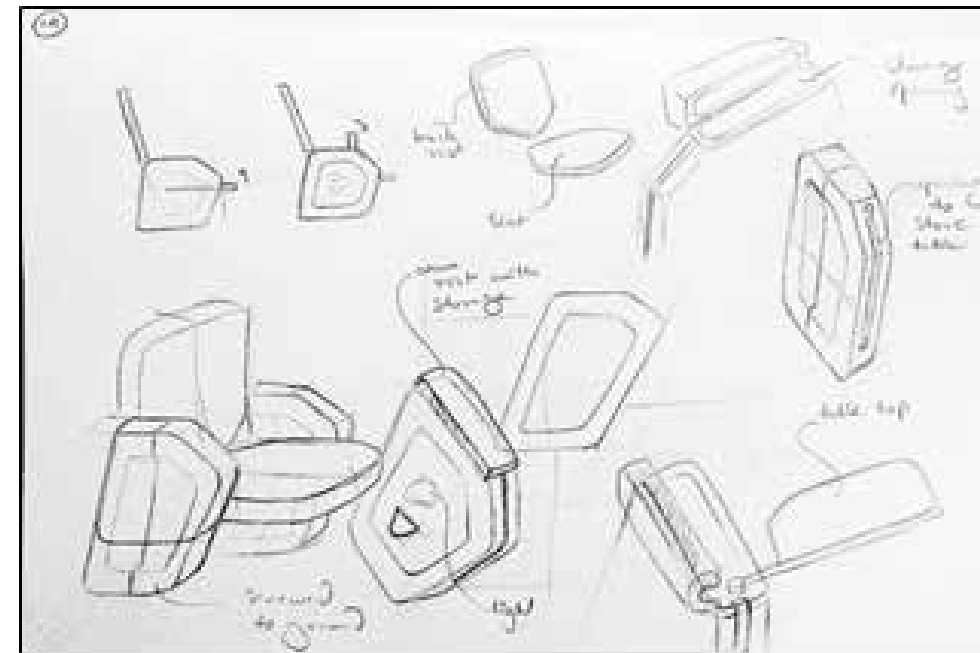
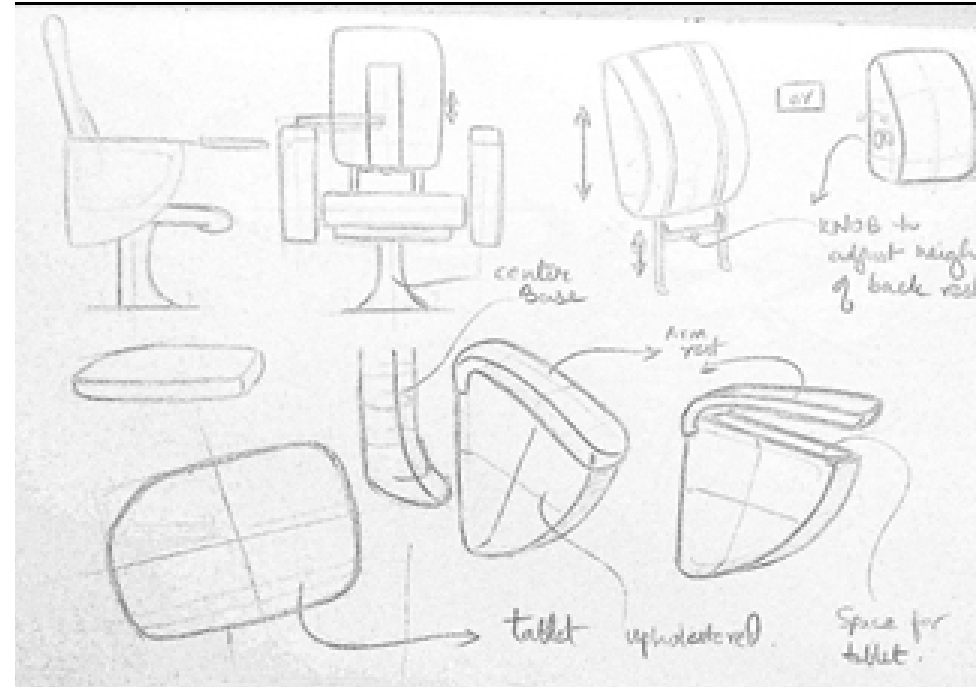
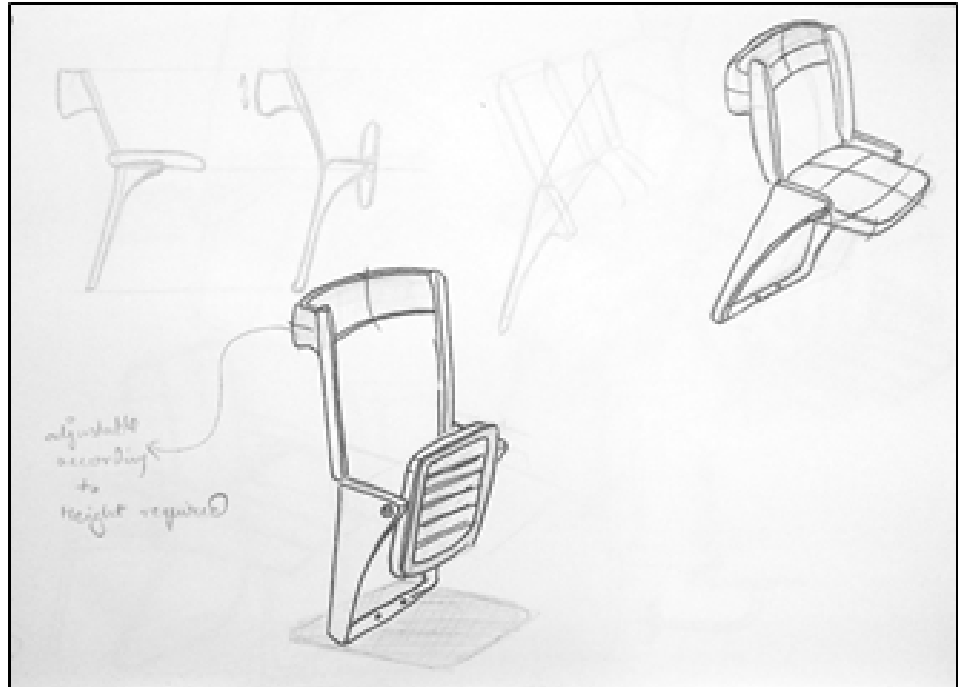
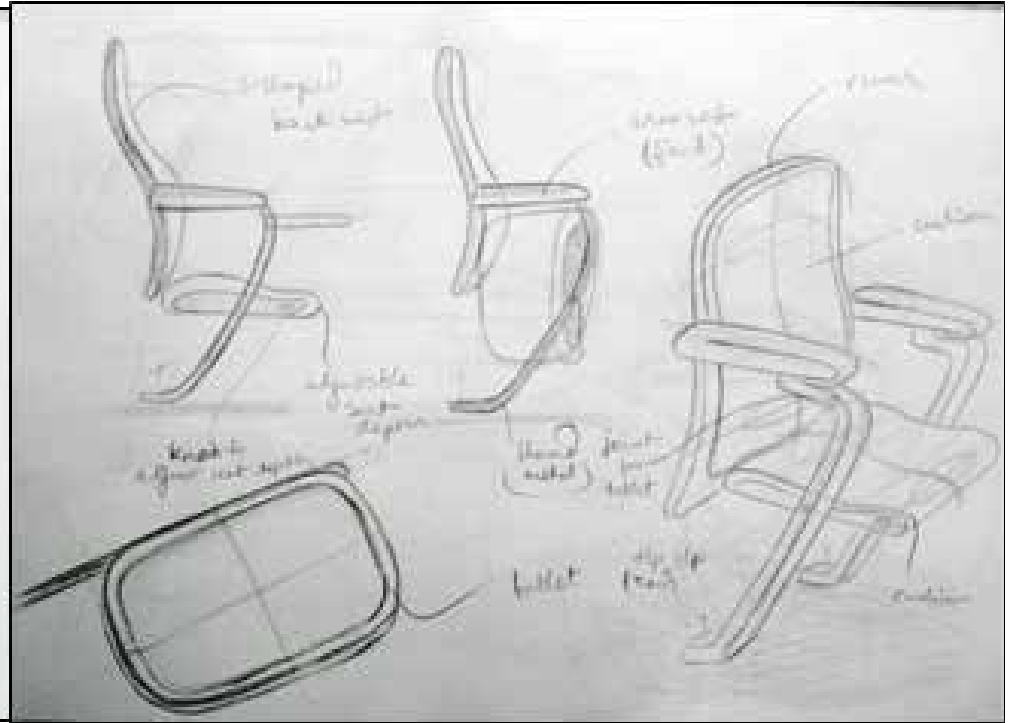
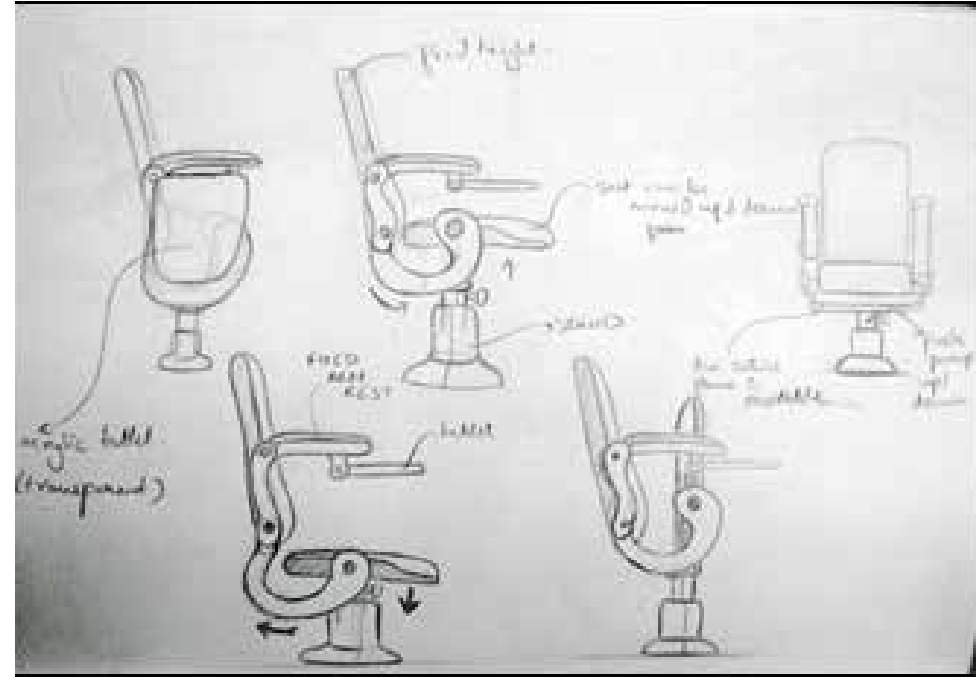
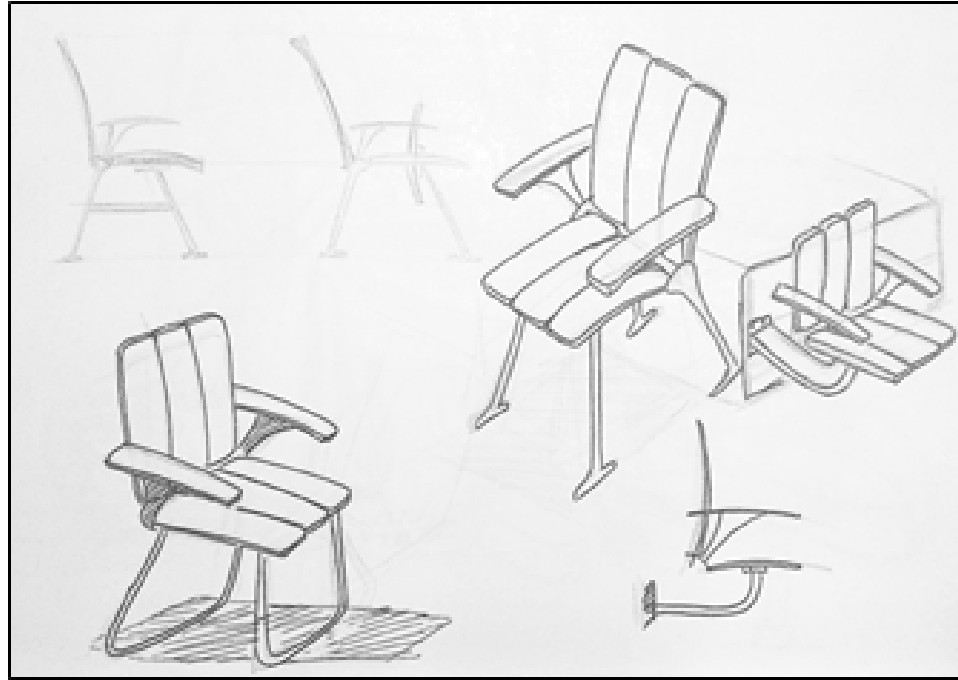
Final deliverable was the plastic back seat pan, plastic seat pan, upholstered back seat design and upholstered seat base design.

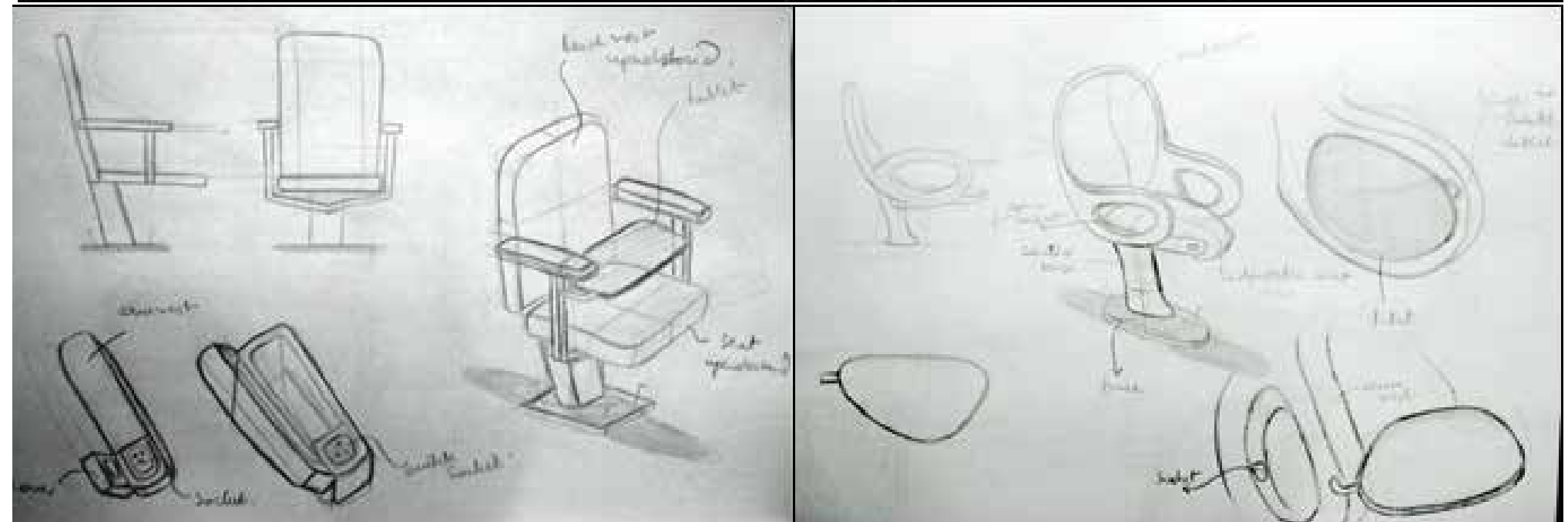
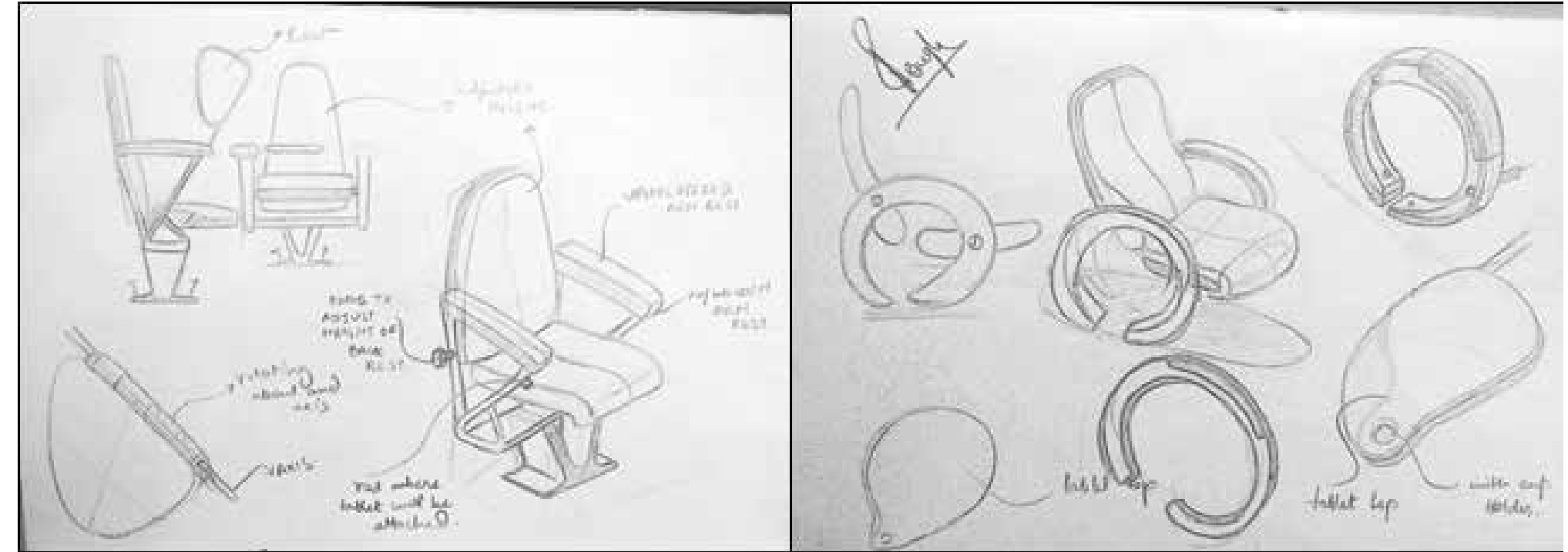
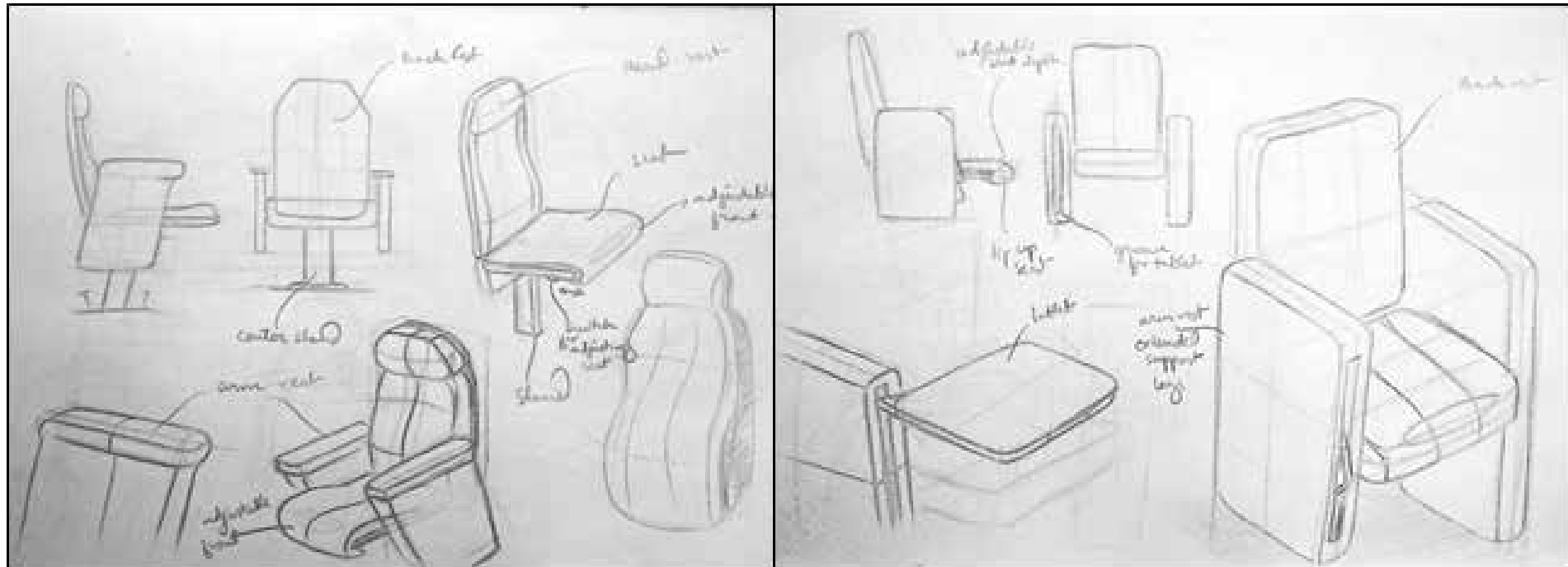
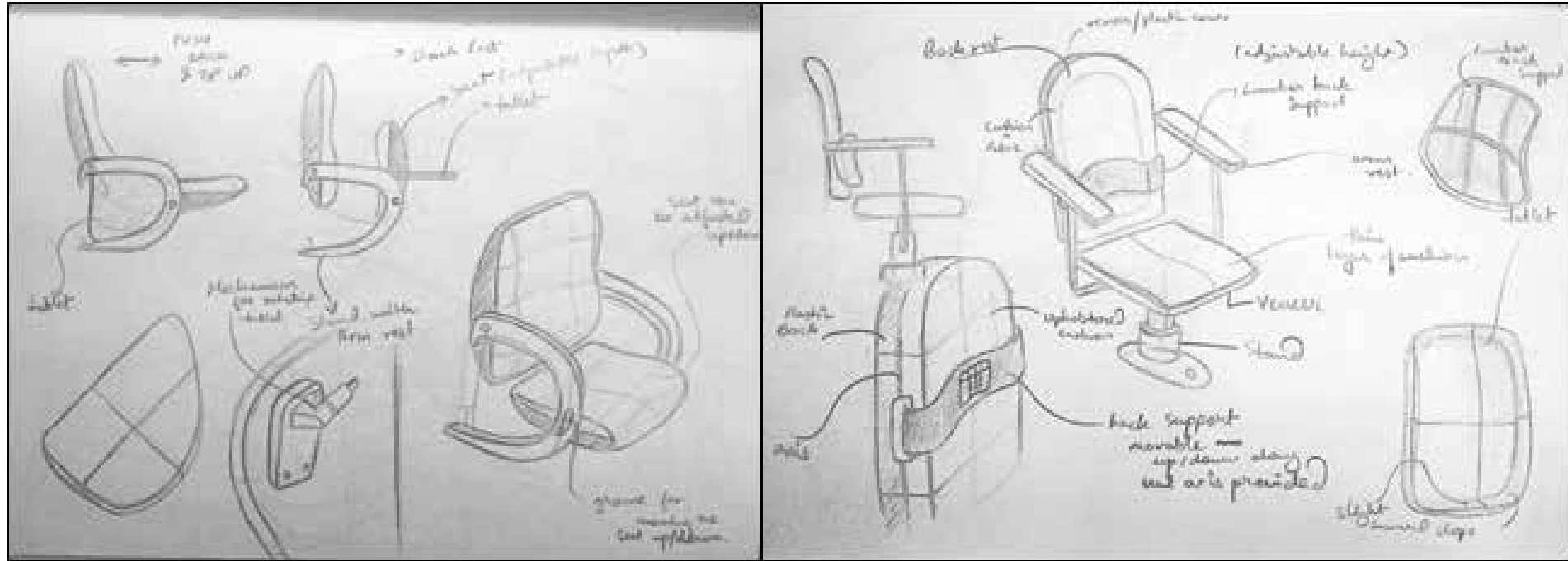
IDEATION

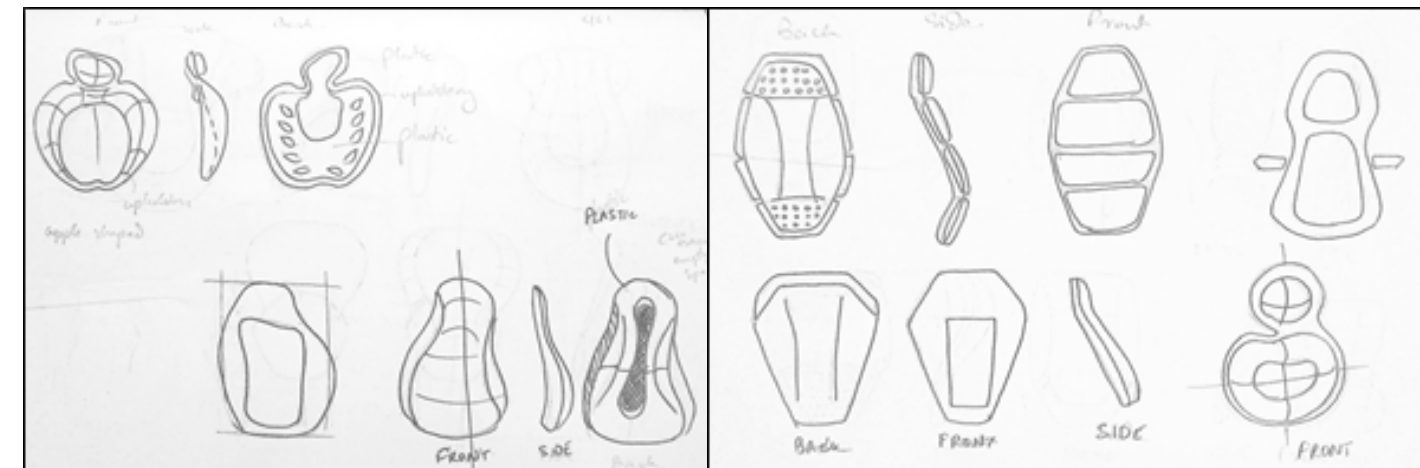
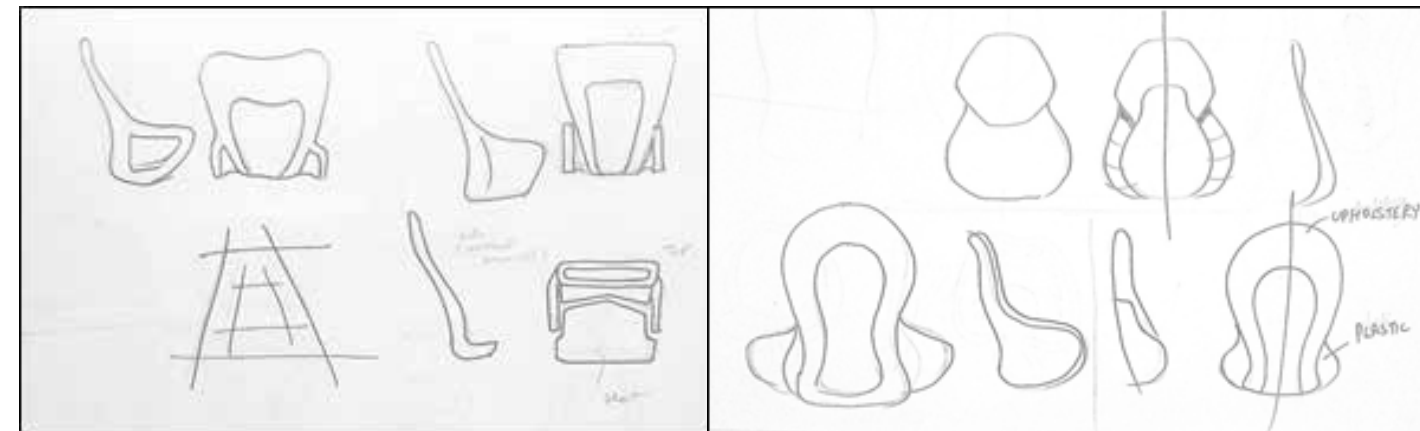
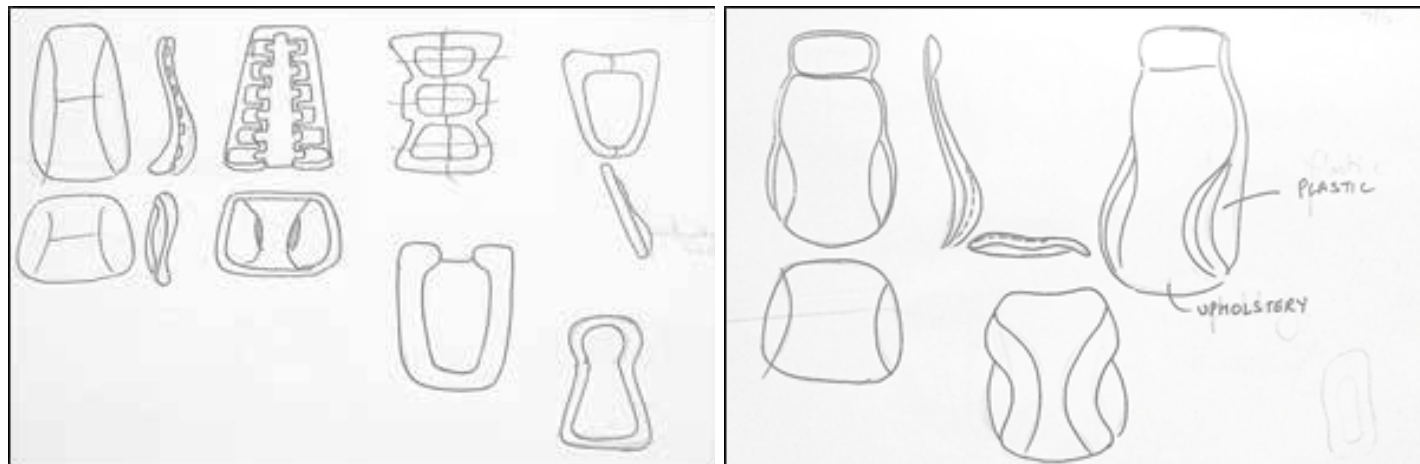
The process of ideation started with formal variations. Trying to include various different designs in my designs. To give a feeling of comfort and easy of use was the main objective of the form. The color should be light to give an effect of lightness and elegance. After analyzing the existing designs and study of the competitors of Nilkamal, different ideas were pen downed. Large variations on the form of back seat and corresponding variations for the seat base and arm rest were created. Most of the ideas were the amalgamation of formal appearance of the car seat, existing auditorium chairs and office chairs.



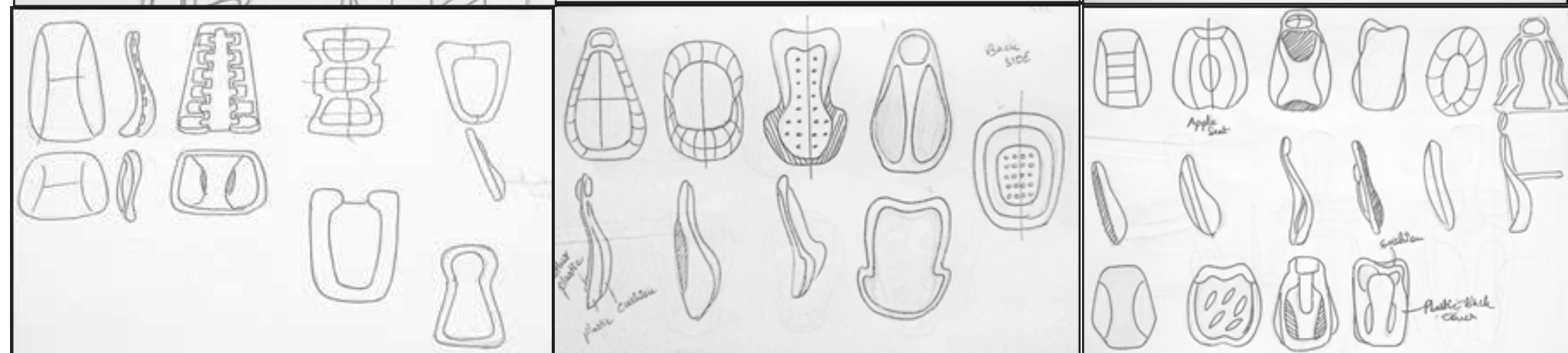
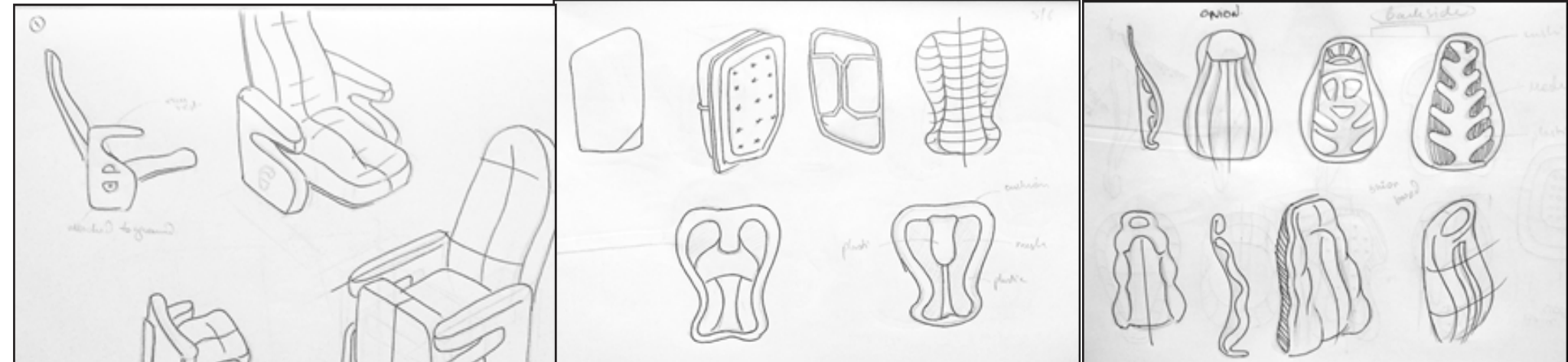
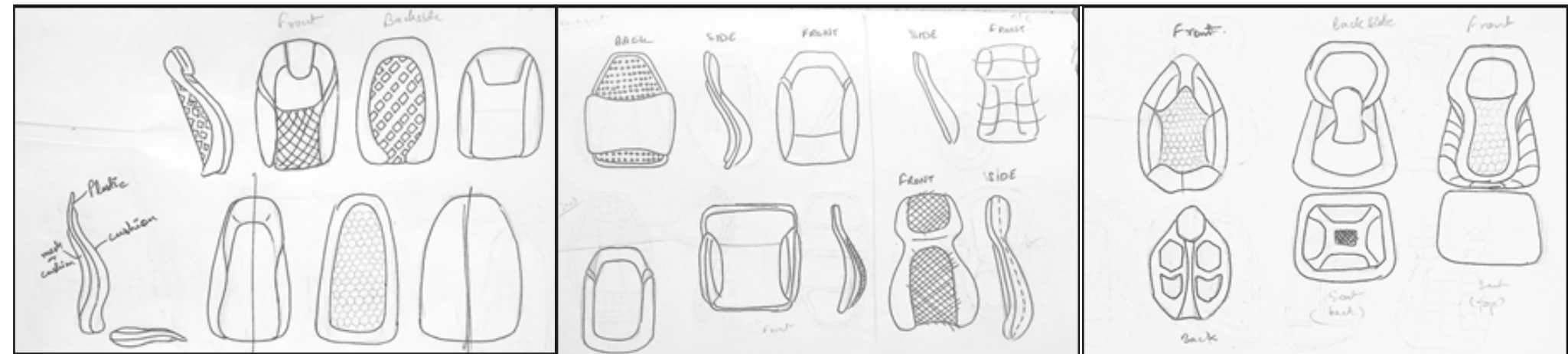




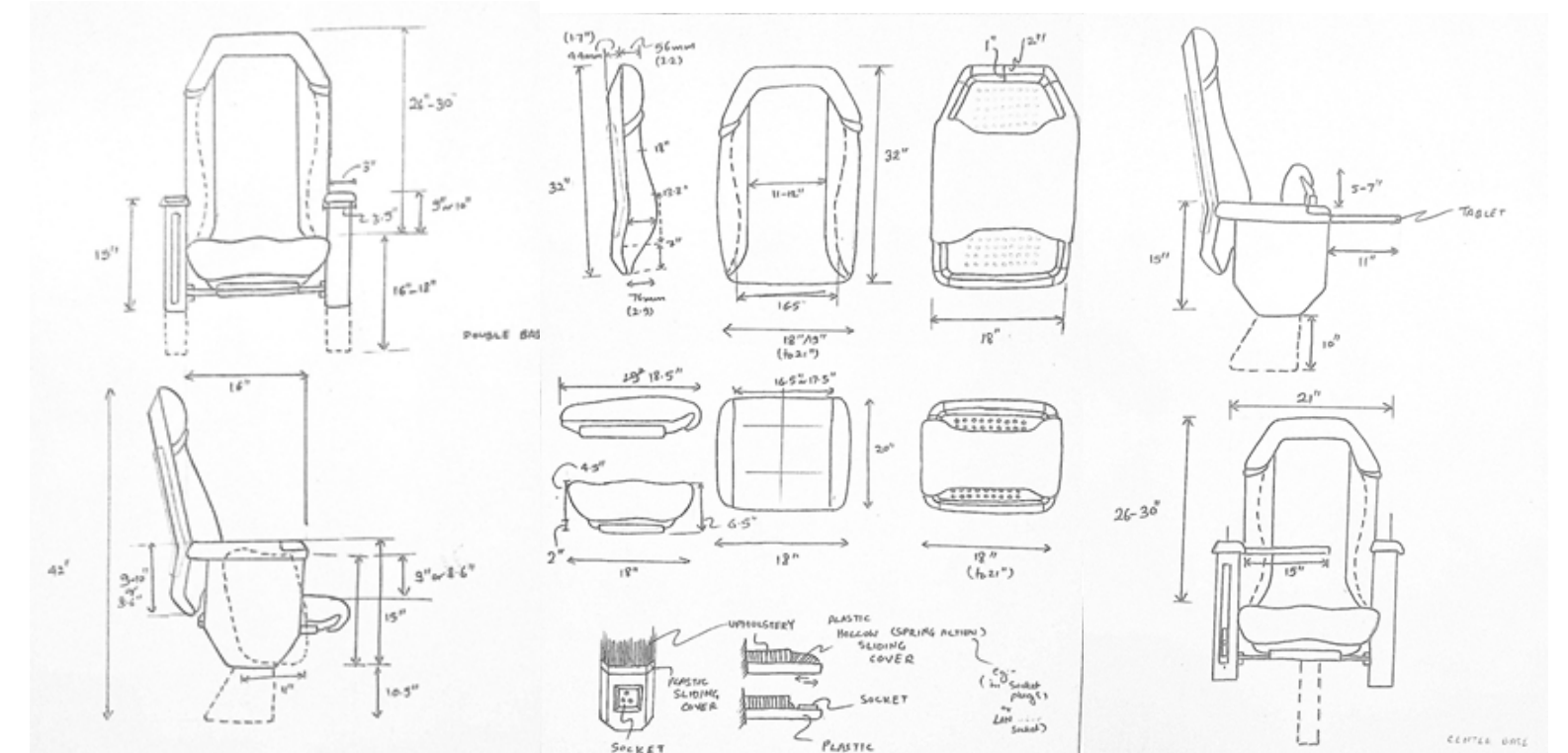




Back and base
of the sea design
exploration:

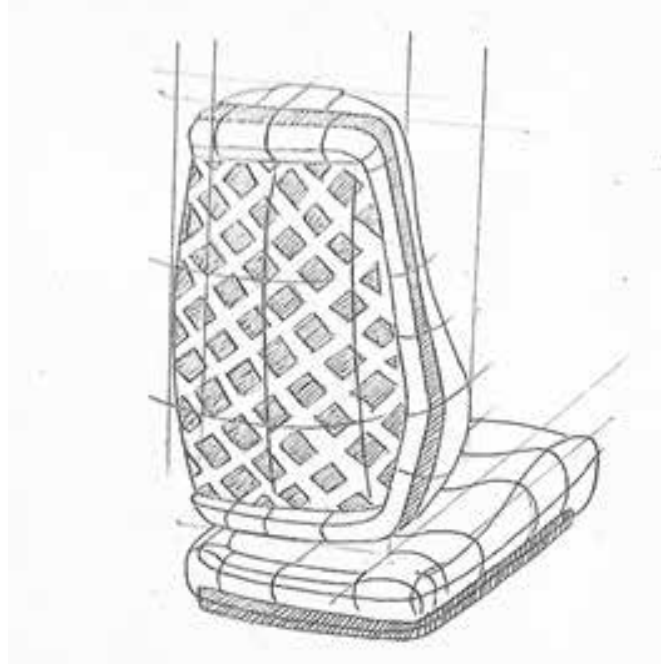
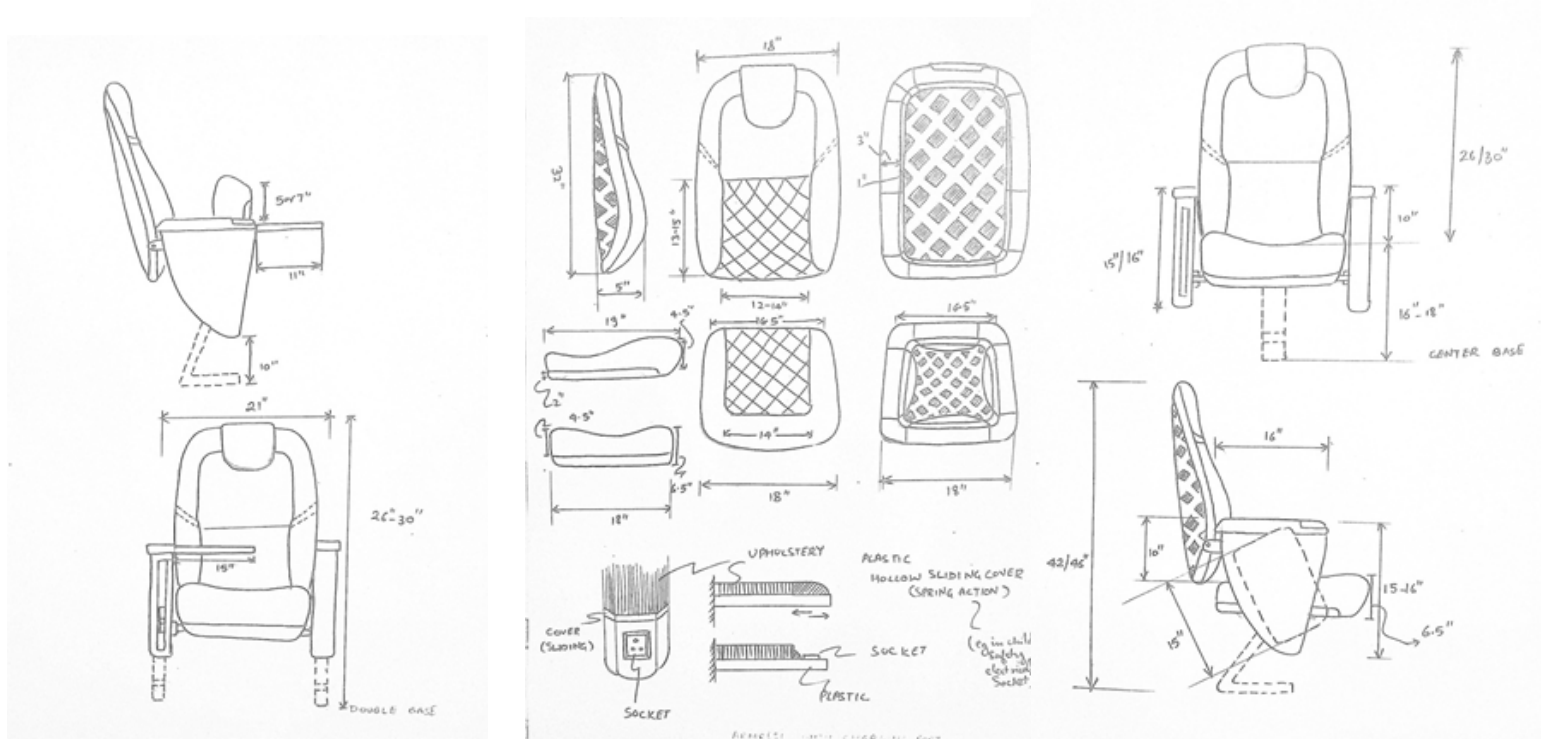


CONCEPTUALIZATION



Concept (1). The first concept was the use of least of folding in the design but still to give a look of comfort and to give an inviting feel to the user. The length of the back seat was kept to cover the persons head as well. A small bend at the lower portion of the back seat to serve the purpose of lumbar back support was given. The seat base was having waterfall front similar to in new designs of office chairs.





Concept (2). The second concept was the evolution of the concept 1, with the provision of built in head rest to more comfort. Here the manufacturing cost will increase a little because of additional material for head rest and its fixing.

3D MODELS



Back of the Seat



Base of the Seat



REFERENCE

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(https://www.profim.eu/Measuring_methodology.pdf) - 24/05
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(<https://www.slideshare.net/VartikaSharma10/auditorium-literature-study-design-considerations>) -09/05
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