1. General Introduction

- Definitions of Transportation Engineering and its Divisions
- History of Transportation
- Urban Road Systems
- Highway System Classification
- Types of Transportation Facilities
1.1 Definition of Transportation Engineering

**Definition:**

Transport engineering (or transportation engineering) is the science of safe and efficient movement of people and goods (transport). It is a sub-discipline of civil engineering.
1.1 Definition of Transportation Engineering

Branches:

<table>
<thead>
<tr>
<th>Transportation Engineering</th>
<th>Planning</th>
<th>Design</th>
<th>Operations and management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>/Urban Planning</td>
<td>/Highway Engineering</td>
<td>/Traffic Engineering</td>
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</tbody>
</table>
1.1 Definition of Transportation Engineering

1. Urban Transportation Planning

- The planning aspects of transport engineering relate to urban planning, and involve technical forecasting decisions and political factors.
1.1 Definition of Transportation Engineering

1. Urban Transportation Planning

- Technical forecasting of passenger travel usually involves an urban transportation planning model, requiring:
  1. the estimation of trip generation (how many trips for what purpose),
  2. trip distribution (destination choice, where is the traveler going),
  3. mode choice (what mode is being taken),
  4. and route assignment (which streets or routes are being used).
1.1 Definition of Transportation Engineering

2. Highway Engineering

- The design aspects of transportation engineering include:
  1. the sizing of transportation facilities (how many lanes or how much capacity the facility has),
  2. determining the materials and thickness used in pavement,
  3. designing the geometry (vertical and horizontal alignment) of the roadway (or track).
1.1 Definition of Transportation Engineering

3. Traffic Engineering

- Operations and management involve traffic engineering, so that vehicles move smoothly on the road or track.
- Older techniques include signs, signals, markings, and tolling.
1.1 Definition of Transportation Engineering

3. Traffic Engineering

- Newer technologies involve intelligent transportation systems, including advanced traveler information systems (such as variable message signs), advanced traffic control systems (such as ramp meters), and vehicle infrastructure integration.
1.1 Definition of Transportation Engineering

3. Traffic Engineering

- Human factors are an aspect of transport engineering, particularly concerning driver-vehicle interface and user interface of road signs, signals, and markings.
1.2 History of Transportation

1.2.1 Roads and Old Modes

- The wheel was invented in 5000 BC years.
- This made necessary the construction of special hard surfaces of roads.
- Ancient roads were built to suit the old mode of transportation (horses, donkeys and carts). Motor vehicles used these roads and in many cases they were not very suitable.
- Roads improve communication and hence civilisation.
- The prosperity of a nation is bound up with the state of its roads.
1.2 History of Transportation

1.2.1 Roads and Old Modes

- **Paving material:**
  1. Granite paving stones ... not comfortable and very noisy
     - The first road was built before 4000 BC
       - From Stone
       - In Iraq (Ur)
  2. Wood paving ... not very successful
     - After stone roads
     - In England
  3. Gravel (3 layers)
     - In England
     - 1800s
     - Fine Gravel and Sand
     - Excavation Stones
     - Large Stones
1.2 History of Transportation

1.2.1 Roads and Old Modes

- **Paving material:**

  3. Bituminous surfacing ... solved the problem

  - The first one was in Paris in **1824**
  - Then after that the new asphalt type in New York in **1872**

- However, solving the problem increased the number of motor vehicles and hence increased the effect on noise, pollution, visual intrusion and community severance.
1.2 History of Transportation

1.2.1 History of Cars

- In 1769, the very first self-propelled road vehicle was a military tractor invented by French engineer and mechanic, Nicolas Joseph Cugnot.

- Cugnot used a steam engine to power his vehicle,

- Speed (2.5 mile/h)

- The vehicle had to stop every ten to fifteen minutes to build up steam power.
1.2 History of Transportation

1.2.1 History of Cars

- In 1771, Cugnot drove one of his road vehicles into a stone wall, making Cugnot the first person to get into a motor vehicle accident.
- This was the beginning of bad luck for the inventor.
- After one of Cugnot's patrons died and the other was injured, the money for Cugnot's road vehicle experiments ended.
- Between 1832 and 1839 Robert Anderson of Scotland invented the first electric car. Electric cars used rechargeable batteries that powered a small electric motor.
- The vehicles were heavy, slow, expensive, and needed to stop for recharging.
1.2 History of Transportation

1.2.1 History of Cars

- Around 1885s, the Early Gasoline-Powered Cars was invented which was better than the electric and steam engine cars.
1.2 History of Transportation

1.2.2 History of Railway

The idea begun in old ages, the roman dug opposite lines in the stone roads, and used wooden wheels drawn by horses.
1.2 History of Transportation

1.2.2 History of Railway

In 1550, Wagon ways were being used in Germany. It consisted of wooden rails over which horse-drawn carts moved with greater ease than over dirt roads.
1.2 History of Transportation

1.2.2 History of Railway

By 1776, iron had replaced the wood in the rails and wheels on the carts. It spread though out Europe, it became called Tramways, Horses still provided all the pulling power.
1.2 History of Transportation

1.2.2 History of Railway

In 1789, Englishman, William Jessup designed the first flanged wheels. It allowed the wheels to better grip the rail, this was an important design that carried over to later locomotives.
1.2 History of Transportation

1.2.2 History of Railway

The invention of the steam engine was critical to the invention of the modern railroad and trains. In 1804, Richard Trevithick built the first steam engine tramway locomotive, in Wales. (Tramways was similar to roads)
1.2 History of Transportation

1.2.2 History of Railway

In, 1825, George Stephenson invented of the first steam locomotive engine for railways for Stockton & Darlington Railroad Company.
1.2 History of Transportation

1.2.2 History of Railway

Stockton & Darlington Company began as the first railroad company to carry both goods and passengers on regular schedules in the world.
1.2 History of Transportation

1.2.2 History of Railway

In, 1897, Werner Siemens designed the first electric Train.
1.2 History of Transportation

1.2.2 History of Railway

In 1912, the first diesel engine used in trains at Germany.
## 1.2 History of Transportation

### 1.2.3 Summary of History of Transportation

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>3500 BC</td>
<td>Fixed <strong>wheels on carts</strong> are invented - the first wheeled vehicles in history. Other early wheeled vehicles include the chariot.</td>
</tr>
<tr>
<td>3500 BC</td>
<td><strong>River boats</strong> are invented - ships with oars</td>
</tr>
<tr>
<td>2000 BC</td>
<td><strong>Horses</strong> are domesticated and used for transportation.</td>
</tr>
<tr>
<td>181-234</td>
<td>The <strong>wheelbarrow</strong> is invented.</td>
</tr>
<tr>
<td>770</td>
<td>Iron <strong>horseshoes</strong> improve transportation by horse</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>------</td>
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</tr>
<tr>
<td>1492</td>
<td>Leonardo da Vinci first to seriously theorize about flying machines - with over 100 drawings that illustrated his theories on flight</td>
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<tr>
<td>1620</td>
<td>Cornelis Drebbel invented the first submarine - an human oared submersible</td>
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<tr>
<td>1662</td>
<td>Blaise Pascal invents the first public bus - horse-drawn, regular route, schedule, and fare system</td>
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<tr>
<td>1740</td>
<td>Jacques de Vaucanson demonstrates his clockwork powered carriage</td>
</tr>
<tr>
<td>1783</td>
<td>First practical steamboat demonstrated by Marquis Claude Francois de Jouffroy d'Abbans - a paddle wheel steamboat</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>1783</td>
<td>The Montgolfier brothers invent the first <a href="#">hot air balloons</a></td>
</tr>
<tr>
<td>1787</td>
<td>Steamboat invented</td>
</tr>
<tr>
<td>1769</td>
<td>First self-propelled <a href="#">road vehicle</a> invented by Nicolas Joseph Cugnot</td>
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<tr>
<td>1790</td>
<td>Modern <a href="#">bicycles</a> invented</td>
</tr>
<tr>
<td>1801</td>
<td><a href="#">Richard Trevithick</a> invented the first steam powered locomotive (designed for roads)</td>
</tr>
<tr>
<td>1807</td>
<td><a href="#">Isaac de Rivas</a> makes a hydrogen gas powered vehicle - first with internal combustion power - however, very unsuccessful design</td>
</tr>
<tr>
<td>1807</td>
<td>First steamboat with regular passenger service - inventor <a href="#">Robert Fulton's Clermont</a></td>
</tr>
<tr>
<td>1814</td>
<td><a href="#">George Stephenson</a> invents the first practical steam powered railroad locomotive</td>
</tr>
<tr>
<td>Year</td>
<td>Event Description</td>
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<tr>
<td>1862</td>
<td>Jean Lenoir makes a gasoline engine automobile</td>
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<tr>
<td>1867</td>
<td>First motorcycle invented</td>
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<tr>
<td>1868</td>
<td>George Westinghouse invents the compressed air locomotive brake - enabled trains to be stopped with fail-safe accuracy</td>
</tr>
<tr>
<td>1871</td>
<td>First cable car invented</td>
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<tr>
<td>1885</td>
<td>Karl Benz builds the world's first practical automobile to be powered by an internal combustion engine</td>
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<tr>
<td>1899</td>
<td>Ferdinand von Zeppelin invents the first successful dirigible - the Zeppelin</td>
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<tr>
<td>1903</td>
<td>The Wright Brothers invent and fly the first engined airplane</td>
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<tr>
<td>1907</td>
<td>Very first helicopter - unsuccessful design</td>
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<tr>
<td>Year</td>
<td>Event</td>
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<tr>
<td>1908</td>
<td>Henry Ford improves the assembly line for automobile manufacturing</td>
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<tr>
<td>1908</td>
<td>Hydrofoil boats co-invented by Alexander Graham Bell &amp; Casey Baldwin - boats that skimmed water</td>
</tr>
<tr>
<td>1926</td>
<td>First liquid propelled rocket launched</td>
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<tr>
<td>1940</td>
<td>Modern helicopters invented</td>
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<tr>
<td>1947</td>
<td>First supersonic jet flight</td>
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<tr>
<td>1956</td>
<td>Hovercraft invented</td>
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<tr>
<td>1964</td>
<td>Bullet train transportation invented</td>
</tr>
<tr>
<td>1969</td>
<td>First manned mission (Apollo) to the Moon</td>
</tr>
<tr>
<td>1970</td>
<td>First jumbo jet</td>
</tr>
<tr>
<td>1981</td>
<td>Space shuttle launched</td>
</tr>
</tbody>
</table>
1.3 Urban Road Systems

There are 3 principal types of road pattern in urban areas.

92 Highway and traffic planning

Fig. 3.7 Basic major road patterns in urban areas: (a) gridiron, (b) linear and (c) radial
1.3 Urban Road Systems

Advantages:
1. Easier for surveyors to set out, using straight lines and rectangular co-ordinates.
2. It encourages an equal spread of traffic over the grid, therefore, the impact at particular location is reduced.
3. It facilitates the implementation of one-way street systems.
4. If there is a central business area in the middle of the grid, it is easy for through traffic to bypass it.

Disadvantages:
1. Extra distances must be travelled when going in a diagonal direction.
2. Providing a diagonal route has an unfortunate effect on the buildings producing acute angles.

Gridiron
Adopted extensively in the USA
1.3 Urban Road Systems

Example of Gridiron System Part Of Gaza
1.3 Urban Road Systems

This type of urban road pattern developed as a result of local topographic difficulties. (Alongside a valley)

**Advantages:**
Main traffic flow is canalised into one major roadway.

**Disadvantages:**
The major roadway serves as a route both to the completely internal traffic and for the internal-external traffic as well as for external-internal and through traffic... This leads to congestion and the major roadway becomes overloaded.

Linear
1.3 Urban Road Systems

Example of Linear System Part Of Nabuls
1.3 Urban Road Systems

- Mainly in old cities.
- A network of roads connecting town centre to town centre. Thus any given town had several roads radiating from its centre to other towns and villages around it.

Advantages:
Providing a direct access to the town centre.

Disadvantages:
1. Concentration of traffic generators within the central area
2. Radial roads converging on the main sources of attraction
3. Lack of suitable bypass routes for through traffic.

In order to minimise these disadvantages, ring roads are used. The ring road is a highway that is roughly circular about the centre of an urban area, and which permits traffic to avoid the centre of this area.

In practice, there are 3 forms of ring roads:
1. an inner ring road
2. an outer ring road
3. intermediate ring roads
1.3 Urban Road Systems

Example of radial System Part Of London
1.4 Highway system classification

Rural roads are classified as follows:

In the USA

Arterial roads
- Principal - interstate
- Minor

Collectors:
- Major
- Minor

Local roads

- Since the cities and larger towns generate and attract a large proportion of the relatively longer trips, the arterial highways generally provide direct service for such travel.

- The intermediate functional category, the collectors, serves small towns directly, connects them to the arterial network, and collects traffic from the bottom-level system of local roads, which serves individual farms and other rural land uses.

Figure II-2

Schematic Illustration of a Functionally Classified Rural Highway Network

Source: http://www.fhwa.dot.gov/planning/fcsec2_1.htm
1.4 Highway system classification

In the USA (continue)

**Urban roads are classified as follows:**

- Arterials:
  - Principal
  - Minor
- Collector streets
- Local streets

- The same basic concepts apply in urban areas as well. A similar hierarchy of systems can be defined;

- However, because of the high intensity of land use and travel throughout an urban area, specific travel generation centers are more difficult to identify.

- In urban areas additional considerations, such as **spacing**, become more important in defining a logical and efficient network. A schematic illustration of a functionally classified urban street network is shown in Figure II-3.

Source: [http://www.fhwa.dot.gov/planning/fcsec2_1.htm](http://www.fhwa.dot.gov/planning/fcsec2_1.htm)
1.4 Highway system classification

In Great Britain

In rural areas:

- Motorways:
  dual carriageway with 3 or more lanes in each direction. The speed limit is 70mph (110 km/h). They connect between major cities (Inter-city).

- A-Roads:
  dual or single carriageway with 2 lanes in each direction. Speed limit is between 60 and 70 mph (95 - 110 km/h).

- B-Roads:
  single carriageway with one lane in each direction. Speed limit is between 50 and 60 mph (80 - 95 km/h).
In Great Britain (continue)

1.4 Highway system classification

In urban areas:

- Primary distributors:
  They serve the town as a whole. They form the primary network for the urban area as a whole, and all longer-distance traffic movements are canalized onto them.

- District distributors:
  They serve large areas within the town. They feed traffic from the primary road network to local areas.

- Local distributors:
  They go through local areas and provide the link between district distributors and access roads.

- Access streets:
  They give direct access to buildings and land.
1.4 Highway system classification

In Gaza (Palestine):

Main Road  Serves for national or inters district traffic

Regional road  Branching off from, or lining, main roads

Access Road  Leading from a main or regional road to a certain point within a locality
1.5 Types of Transportation Facilities

Facilities may generally be classified into one of two categories:
1.5 Types of Transportation Facilities

**Uninterrupted Flow Facilities**
They have no fixed elements, such as traffic signals and stop signs, that cause interruption to traffic flow. Examples of Uninterrupted flow facilities are freeway two-lane highway and multilane highway.

**Interrupted Flow Facilities**
They have fixed elements causing periodic interruption to traffic flow. Examples of interrupted flow facilities are signalised intersections, Unsignalized intersections (stop or yield controlled approach), and arterial.
1.5 Types of Transportation Facilities

**Uninterrupted-Flow Facilities**

<table>
<thead>
<tr>
<th>Basic Freeway Sections</th>
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<tr>
<td>Weaving Areas</td>
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<tr>
<td>Ramps and Ramp Junctions</td>
</tr>
<tr>
<td>Freeway Systems</td>
</tr>
<tr>
<td>Multilane Rural and Suburban Highways</td>
</tr>
<tr>
<td>Two-Lane Highways</td>
</tr>
</tbody>
</table>
1.5 Types of Transportation Facilities

Interrupted-Flow Facilities

- Signalized Intersections
- Unsignalized Intersections
- Arterial Streets
- Transit Capacity
- Pedestrians
- Bicycles