

**Solution IAT-2  
October 2018**



Sub:	TRAFFIC ENGINEERING	Sub Code:	15CV561	Branch:	CIVIL
<b>PART A is compulsory and answer any TWO questions from Part B</b> <i>Assume any missing data suitably.</i>					MARKS
<b>PART A</b>					
1 (a)	Outline the causes of accidents and suggest remedial measures for prevention				[08]
	<p>Engineering-3 Enforcement-3 Education -2</p> <p>3 E's such as Engineering, Enforcement and Education can be utilized to reduce accidents.</p> <p><b><u>Safety measures related to engineering</u></b></p> <p>Road designs:</p> <ul style="list-style-type: none"> <li>➤ Sight distances, width , horizontal and vertical alignment, intersection design elements</li> <li>➤ Pavement surface characteristics, skid resistance values</li> <li>➤ Necessary bypasses may be constructed</li> <li>➤ Grade separated intersections</li> </ul> <p>Preventive maintenance of vehicle</p> <ul style="list-style-type: none"> <li>➤ braking system, steering system, lighting system should be checked regularly</li> <li>➤ Heavy penalty on defective vehicles</li> <li>➤ Special checks on public carriers</li> </ul> <p>Before and after study</p> <ul style="list-style-type: none"> <li>➤ By comparing the condition and collision diagnosis “before and after” the introduction of preventive measures</li> <li>➤ After necessary improvements in design and enforcing regulation</li> </ul> <p>Road lighting</p> <ul style="list-style-type: none"> <li>➤ Proper road lighting especially at the intersections, bridge sites and at places where there are restriction in traffic movement</li> </ul> <p><b><u>Safety measures related to enforcement</u></b></p> <p>Speed control:</p> <ul style="list-style-type: none"> <li>➤ Checks on spot speed of all vehicles should be done at different locations and timings and legal actions on those who violate the speed limit should be taken</li> </ul> <p>Training and supervision</p> <ul style="list-style-type: none"> <li>➤ The transport authorities should be strict while issuing licence to drivers of public service vehicles and taxis.</li> <li>➤ Driving licence of the driver may be renewed after specified period, only after conducting some tests to check whether the driver is fit</li> </ul> <p>Medical check</p> <p>The drivers should be tested for vision and reaction time at prescribed intervals of time</p> <p><b><u>Safety Measures related to education</u></b></p> <p>The various measures of education that may be useful to prevent accidents are enumerated below.</p> <p>Education of road users:</p> <ul style="list-style-type: none"> <li>➤ The passengers and pedestrians should be taught the rules of the road, Correct manner of crossing etc.</li> <li>➤ Introducing necessary instruction in the schools for the children and</li> <li>➤ Posters exhibiting the serious results due to carelessness of road users.</li> </ul> <p>Safety drive: Documentaries and films for road users and drivers</p> <ul style="list-style-type: none"> <li>➤ Training courses and workshops</li> <li>➤ Imposing traffic safety weeks</li> </ul>				

(b)	What are the major sources of traffic related noise pollution? Explain. Also list the controlling methods of noise pollution by traffic	[06]																		
Major sources – 3 Control methods -3																				
<p><i>Noise pollution</i> Noise is the unwanted sound. Noise in cities is the result of a number of activities such as road traffic, aircraft, railways and industrial and constructional works.</p> <p><i>Effect of noise:</i> This can be classified into three</p> <ul style="list-style-type: none"> <li>(i) Subjective effects: this include disturbance, noisiness etc and is difficult to be measured.</li> <li>(ii) Behavioral effects: the noise can influence the behavior of people like sleeplessness, disturbance in studies, distraction in student's mind etc.</li> <li>(iii) Physiological effects: it can cause startle or fright phenomenon. Considerable exposure can even cause deafness</li> </ul> <p><i>Generation of noise is by</i></p> <ul style="list-style-type: none"> <li>(i) Various parts of the vehicle.</li> <li>(ii) Interaction between vehicle and road surface</li> <li>(iii) Noise dependent upon speed, flow and density of traffic.</li> <li>(iv) Horns- Congestion on the road can increase noise</li> </ul> <p><i>Abatement measures:</i></p> <ul style="list-style-type: none"> <li>(i) Change in the design of vehicles- in India, Motor vehicles Act has made provisions to frame rules to control te noise produced by motor cycles.</li> <li>(ii) Changes in tyre/ surface characteristics- smooth surfaces result in less noise.</li> <li>(iii) Elimination of noisier vehicles- old vehicles produce more sound.</li> <li>(iv) Modifications in traffic operations- rerouting commercial vehicles and buses from residential areas, providing by-pass to prevent high speed traffic from entering towns, ensure continuous and smooth and eliminate acceleration noise, prohibiting blow horns.</li> <li>(v) Designing streets, buildings and areas for producing less noise- narrow streets create noise conditions (canyon effect). Hence, streets should be wide to reduce noise pollution. Shrubs, trees and grass on the side of the road act as sound barriers.</li> </ul>																				
(c)	What are the major air pollutants due to road traffic? Explain consequences of each	[06]																		
Each pollutant and its consequence – 6																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 20%;">Pollutant</th> <th style="width: 30%;">Source</th> <th style="width: 50%;">Consequences</th> </tr> </thead> <tbody> <tr> <td><b>NO<sub>2</sub></b></td> <td>Vehicular exhaust</td> <td>It forms smog and ozone, It causes respiratory illness, pulmonary disease, bronchitis etc</td> </tr> <tr> <td><b>CO</b></td> <td>Vehicle's exhaust as a result of incomplete combustion, Emissions from trucks, autos are significant</td> <td>It interferes with the blood's ability to carry oxygen to the brain, heart, and other tissues. Unborn or newborn children and people with heart disease are in greatest danger from this pollutant, but even healthy people can experience headaches, fatigue and reduced reflexes and even death</td> </tr> <tr> <td><b>SO<sub>2</sub></b></td> <td>Fuel containing sulfur is burned in diesel engines</td> <td>Asthma, lung diseases, irritate mucus membrane, bronchitis, pulmonary diseases It can effect plants, animals and also properties</td> </tr> <tr> <td><b>O<sub>3</sub></b></td> <td>Secondary formation from the vehicular exhaust gases such as reaction of NO<sub>2</sub></td> <td>It forms smog, ozone reacts with lung tissue. It can inflame and cause harmful changes in breathing passages, decrease the lungs' working ability, and cause coughing and chest pains.</td> </tr> <tr> <td><b>Particulate matter (PM)</b></td> <td>Particulate matter includes microscopic particles and tiny</td> <td>PM are very fine in size and they go deep into the lungs, where they may become trapped and cause</td> </tr> </tbody> </table>			Pollutant	Source	Consequences	<b>NO<sub>2</sub></b>	Vehicular exhaust	It forms smog and ozone, It causes respiratory illness, pulmonary disease, bronchitis etc	<b>CO</b>	Vehicle's exhaust as a result of incomplete combustion, Emissions from trucks, autos are significant	It interferes with the blood's ability to carry oxygen to the brain, heart, and other tissues. Unborn or newborn children and people with heart disease are in greatest danger from this pollutant, but even healthy people can experience headaches, fatigue and reduced reflexes and even death	<b>SO<sub>2</sub></b>	Fuel containing sulfur is burned in diesel engines	Asthma, lung diseases, irritate mucus membrane, bronchitis, pulmonary diseases It can effect plants, animals and also properties	<b>O<sub>3</sub></b>	Secondary formation from the vehicular exhaust gases such as reaction of NO <sub>2</sub>	It forms smog, ozone reacts with lung tissue. It can inflame and cause harmful changes in breathing passages, decrease the lungs' working ability, and cause coughing and chest pains.	<b>Particulate matter (PM)</b>	Particulate matter includes microscopic particles and tiny	PM are very fine in size and they go deep into the lungs, where they may become trapped and cause
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	droplets of liquid which comes from combustion of the fuel in vehicles	irritation. Exposure to particulate matter can cause wheezing, asthma, respiratory illness, PM can serve as a vector for toxic air pollutants which may be carcinogenic
<b>Lead</b>	Lead can emitted from leaded petrol, However, usage of un leaded petrol resulted in significant drop in public exposure to outdoor lead pollution	Lead poisoning can reduce mental ability, damage blood, nerves, and organs, and raise blood pressure. Even small ingestions or inhalations of lead can be harmful because lead accumulates in the body
<b>Hydrocarbons</b>	Vehicular exhaust	Many hydrocarbons are carcinogenic

**PART B**

2 (a) Write short notes on Condition diagram and collision diagram [04]

Condition diagram +Collision diagram -2+2

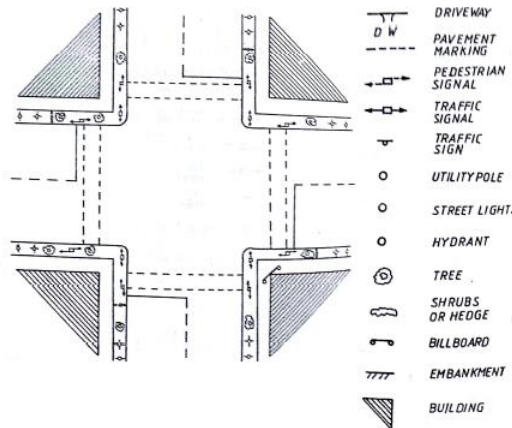
**Condition Diagram:**

- This is a diagram of the accident location drawn to scale.
- It shows important features of the road and adjoining area using standard symbols.
- Important features include width of roadway, shoulders, median, curves, kerb lines, bridges, culverts, trees, electric post, traffic signs and signals

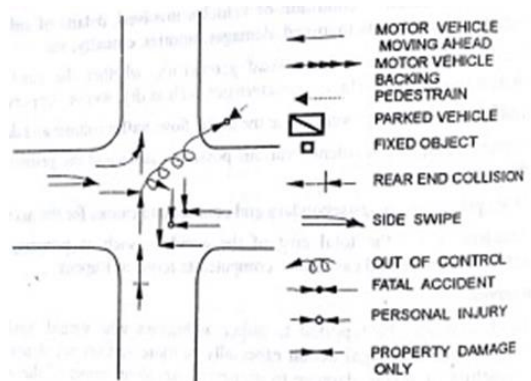
**Collision diagram:**

- Depict the details of accident location, but not to scale using standard symbols.
- Show the approximate path of the vehicles and pedestrians involved in the accident.
- Collision diagram helps in comparing the accident pattern before and after remedial measures have been taken.

Condition diagram



Collision diagram

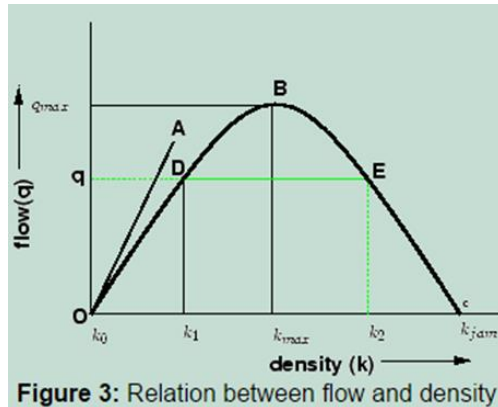
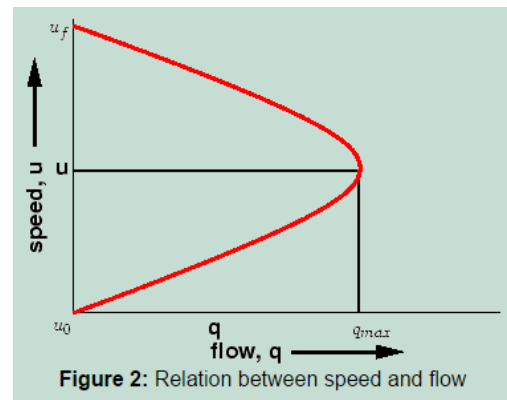
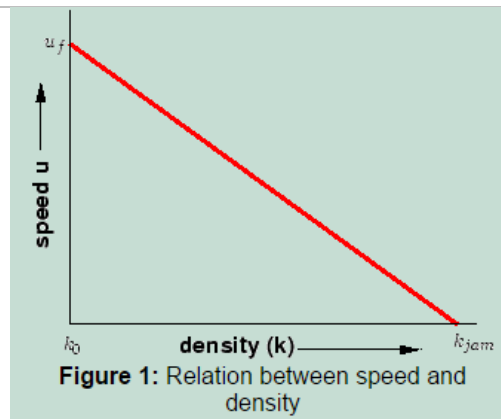


(b) Describe Fundamental flow diagram [04]

Figure- 2 marks  
Explanation-2 marks

**Fundamentals flow diagram**

Macroscopic stream models represent how the behaviour of one parameter of traffic flow changes with respect to another. Most important among them is the relation between speed and density. The first and most simple relation between them is proposed by Greenshield. Greenshield assumed a linear speed-density relationship as illustrated in figure 1



The equation for this relationship is shown below.

$$v = v_f - \left[ \frac{v_f}{k_j} \right] \cdot k$$

where  $v$  is the mean speed at density  $k$ ,  $v_f$  is the free speed and  $k_j$  is the jam density. This above equation is often referred to as the Greenshields' model. It indicates that when density becomes zero, speed approaches free flow speed

Similarly when the flow is less, density will be very less. As flow increases, traffic density decreases and speed decreases. When the vehicles are in jam condition also flow will be zero.

Density Vs Flow:

- When **density is zero, flow** will also be **zero**, since there is no vehicles on the road.
- When the number of vehicles gradually increases the density as well as flow increases.
- When more and more vehicles are added, it reaches a situation where vehicles can't move. This is referred to as the **jam density** or the maximum density.
- At jam density, flow will be zero because the vehicles are not moving.
- There will be some density between zero density and jam density, when the flow is maximum. The relationship is normally represented by a parabolic curve
- O refers to the case with zero density and zero flow.
- The point C refers to the maximum density  $k_{jam}$  and the corresponding flow is zero.
- OA is the tangent drawn to the parabola at O, and the slope of the line OA gives the mean free flow speed.

Speed-density

- Speed will be maximum, referred to as the free flow speed, and when the density is maximum, the speed will be zero.
- The most simple assumption is that this variation of speed with density is linear

Speed-flow

- The flow is zero either because there are no vehicles or there are too many vehicles so that they cannot move.
- At maximum flow, the speed will be in between zero and free flow speed.

- The maximum flow  $q_{\max}$  occurs at speed  $u$
- It is possible to have two different speeds for a given flow.

(c) The data of table shows the occupancy of parking spaces in a parking lot consisting of 50 spaces. The count was taken as 15 minute interval during 4 hours duration between 11 AM and 3 PM on 6 week days (Monday to Saturday). Find by inspection whether the number of vacant spaces during any count follow Poisson's distribution

[07]

Occupancy of parking space	50	49	48	47	46	45	44	43	42	41	40 and less
Observed Frequency	6	15	21	20	15	10	5	2	1	1	0

Estimation of total vacant spaces+theoretical probability and theretical frequency – 2+2+2 = 6  
Comment on Poisson distribution -1

$$P(r) = \frac{m^r e^{-m}}{r!}$$

No. of vacant spaces	Observed frequency	Total vacant spaces	Theoretical Probability	Theoretical frequency 4x96
0	6	0	0.0498	4.8
1	15	15	0.1494	14.3
2	21	42	0.2241	21.5
3	20	60	0.2241	21.5
4	15	60	0.1681	16.5
5	10	50	0.1009	9.6
6	5	30	0.0505	4.8
7	2	14	0.0216	2.1
8	1	8	0.0081	0.8
9	1	9	0.0027	0.3
10 or more	0	0	0.0007	0.1
	$\sum f_i = 96$	288	$\sum = 1.00$	$\sum = 96.00$

$$m = \frac{288}{96} = 30 \text{ vacant spaces/ count}$$

$r = 0, 1, 2, \dots, 9, 10 \text{ or more}$

It follows a Poissons distribution

3 (a) Define PCU. What are the different factors affecting PCU.

[04]

Definition- 1  
Factors-2.5  
Typical values -0.5

Passenger Car Unit (PCU) is a metric used in Transportation Engineering, to assess traffic-flow rate on a highway. A Passenger Car Unit is a measure of the impact that a mode of transport has on traffic variables (such as headway, speed, density) compared to a single standard passenger car. This is also known as passenger car equivalent. For example, typical values of PCU are:

Vehicle type	PCU
Car	1
Motorcycle	0.5
Bicycle	0.2
LCV	2.2
Bus, truck	3.5
3-wheeler	0.8

The different factors affecting PCU are

1. Average length and width of the vehicle
2. Average speed of the vehicle
3. Average transverse and longitudinal gap allowed between the vehicles
4. Traffic location – midblock, intersection, rotary etc
5. Parking on roads – reduce capacity of the road
6. Road geometrics like width of road, presence of median, footpaths, curves etc
7. Composition of traffic

(b) Mention various applications of “O and D” study. What are the different methods of presenting O-D data.

[04]

Applications of O-D study – 2  
 Methods of presenting - 2

**The following objectives are identified for O-D studies:**

- To judge the adequacy of existing routes and to plan new network of roads.
- To establish design standards for th road, bridges and culverts along the route
- To locate expressways or major routes along the desire lines.
- To establish preferential routes for various categories of vehicle including by-pass.
- To locate new bridges as per traffic demands
- To plan transportation system and mass transit facilities in cities including routes and schedules of operation.
- To locate terminals and to plan terminal facilities.
- To locate intermediate stops of public transport.

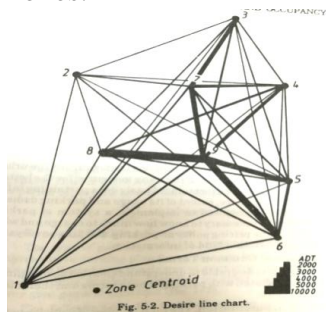
**Methods of presenting O-D data**

**The data can be resented in the following ways:**

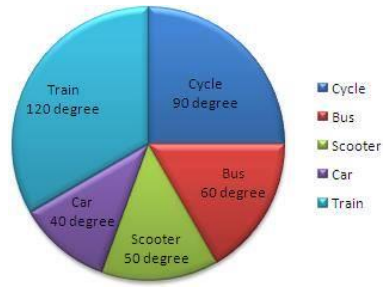
1. Origin and destination table: here the data is presented in the form of a matrix with I representing origin and j representing destination.

		Destination				
		1	2	3		j
Origin	1	T <sub>11</sub>	T <sub>12</sub>	T <sub>13</sub>		T <sub>1j</sub>
	2	T <sub>21</sub>	T <sub>22</sub>	T <sub>23</sub>		T <sub>2j</sub>
	3	T <sub>31</sub>	T <sub>32</sub>	T <sub>33</sub>		T <sub>3j</sub>
	i	T <sub>i1</sub>	T <sub>i2</sub>	T <sub>i3</sub>		T <sub>ij</sub>

2. Desire line diagram : here the thickness of lines indicates the trips made between two zones.



3. Pie charts: the pie charts can be made to classify the trip based on commuters, mode of travel, age and so on.



4. Contour lines: indicate the general traffic in an area

(c)

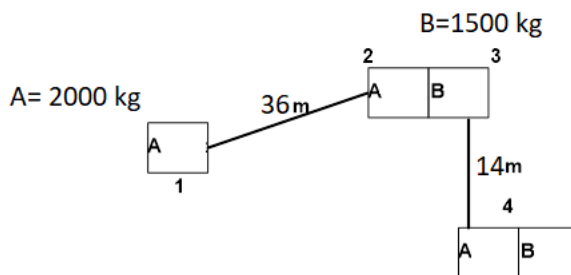
A vehicle of 2000 kg skids a distance of 36 m before colliding with a stationary vehicle of 1500 kg weight. After collision both vehicle skid a distance of 14 m. Assuming coefficient of friction 0.5, determine the initial speed of the vehicle. (i) after collision (ii) at collision (iii) before collision.

[07]

After collision – (2)

At collision –(3)

Before collision- (2)



**After collision (path 3-4):**

$$u = v_{A3}$$

$$v = 0$$

$$v^2 = u^2 + 2aS$$

$$0 = (v_{A3})^2 - 2 \times 0.5 \times 9.81 \times 14$$

$$v_{A3} = 11.72 \text{ m/s}$$

**At collision (path 2-3):**

Principle of conservation of momentum

$$W_A \times v_{A2} + W_B \times 0 = (W_A + W_B) \times v_{A3}$$

$$2000 \times v_{A2} + 1500 \times 0 = (3500) \times 11.72$$

$$v_{A2} = 20.51 \text{ m/s}$$

**Before collision (path 1-2):**

$$u = v_{A1}$$

$$v = v_{A2}$$

$$v^2 = u^2 + 2aS$$

$$20.51^2 = (v_{A1})^2 - 2 \times 0.5 \times 9.81 \times 36$$

$$v_{A1} = 27.81 \text{ m/s}$$

4 (a)

Discuss the various types of parking, their advantages and disadvantages

[04]

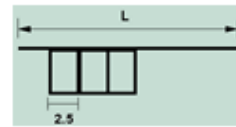
Types listing with Advantages /disadvantages -4

On street parking

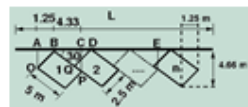
- Parallel parking
- 30° angle parking
- 45° angle parking
- 60° angle parking
- 90° angle parking



**Parallel parking**



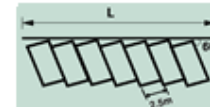
**Perpendicular parking**



**30 degree parking**



**45 degree parking**



**60 degree parking**

- Here the parking is done on road. Parallel parking consumes maximum kerb length, and minimum is consumed by perpendicular parking.
- Parallel parking consumes least width of the street
- Manoeuvrability is better for angle parking.

Off street parking:

- Surface car parks:  
They are located in a vacant piece of land surrounding an official complex or supermarket.  
If there is a fee collecting mechanism, arrangements should be made for the same.
- Multi storey car parks  
Normally designed for a capacity of 400-500 cars.  
Ventilation should be provided  
Gradient of the ramp: 1 in 10  
Inside radius – 7m  
Width : 3.75 m
- Roof parks: can be done using access ramps or lifts  
Great care is required for the design of structural elements
- Mechanical car parks  
Here a mechanical lift is provided to lift the car such that a parking lot can be used by more than one vehicle.
- Underground parks  
Least influence on aesthetics  
Proper ventilation and drainage is a must.  
Generally provided in the basement of multi-storeyed buildings or malls

(b) Write short notes on  
i) Level of service iv) Desire line diagram

[04]

Level of service- 2  
Desire line diagram- 2

**Level of service** This is defined as a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience.  
Six LOS are defined for each type of facility

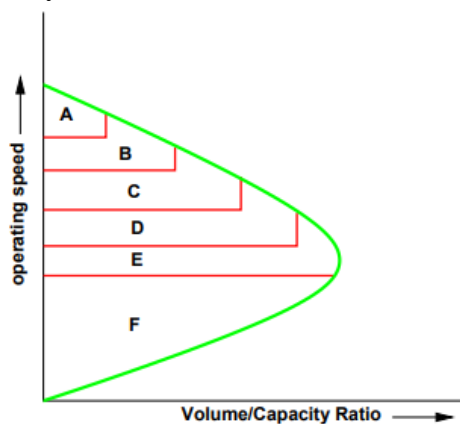


LOS are designated using letter A to F

LOS A represents best operating conditions and LOS F is the worst

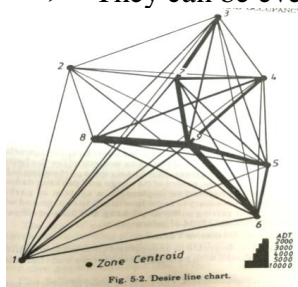
Each LOS represents a range of operating conditions and the driver's perception of those conditions.

Safety is not included in the measures to establish LOS



**Desire lines:**

- **Graphical representation** of O and D survey data.
- Desire lines are straight lines **connecting** the **origin** with **destination**, summarized in different zones.
- **Width** of the desire lines is drawn proportional to the **no of trips in both directions**.
- This map expresses the **actual desire** of road users and helps the planners to fine the **necessity** of a new link or **diversion/bridge**.
- They can be even completed with the existing flow pattern



(c) Speed and concentration of vehicles in a traffic stream were observed and the following data were obtained

[07]

K (vehicle/km)	5	10	15	20	25	30	35	40	45	50
V (kmph)	72	68	61	52	47	39	32	27	20	13

Find the regression equation for determining speed from concentration

Column on  $xy$  + column of  $x^2 = 4$

Estimation of  $b$ ,  $a$  and equation  $-1+1+1$

$x, K$ (VPH)	5	10	15	20	25	30	35	40	45	50	275	27.5
$y, V$ (KMPH)	72	68	61	52	47	39	32	27	20	13	431	43.1
$xy$	360	680	915	1040	1175	1170	1120	1080	900	650	9090	
$(x_i)^2$	25	100	225	400	625	900	1225	1600	2025	2500	9625	

$$\check{b} = \frac{\sum x_i y_i - n \bar{x} \bar{y}}{\sum x_i^2 - n (\bar{x})^2} = \frac{9090 - 10 \times 27.5 \times 43.1}{9625 - 10 \times 27.5 \times 27.5} = -1.34$$

$$\check{a} = \check{y} - \check{b} \bar{x} = 43.1 - (-1.34) \times 27.5 = 79.95$$

So the equation is  $V = 79.95 - 1.4 K$