PRACTICAL LESSON #1 ANALYSIS OF LAYOUT DIAGRAMS OF MECHANICAL TRANSMISSIONS OF CARS

Duration of work 4 hours. **Purpose of the work**

To master the skills of analysis and calculation of layout diagrams of mechanical transmissions of automobiles.

1. Basic Provisions

Everything that connects the engine to the drive wheels is the vehicle's transmission. The transmission in a vehicle performs the following functions:

– transmits torque from the engine to the drive gears forests;

– changes the magnitude and direction of torque;

– redistributes torque between the drives wheels.

In the transmission design, the front, rear, or both front and rear wheels can be used as drive wheels. If the rear wheels are used as drive wheels, the car has rear-wheel drive, and if the front wheels are used, it has front-wheel drive. All-wheel drive vehicles have both front and rear wheel drive.

In cars with different types of drive, the transmission design has significant differences both in the composition of the elements and in their structure.

2. Contents of lesson No. 1

Task No. 1. Analysis of vehicle layout diagrams

Using sources [1, 2, 4], study the design schemes of mechanical transmissions of cars and determine

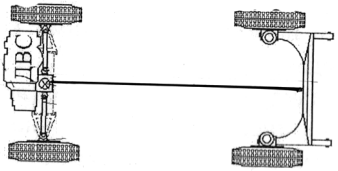
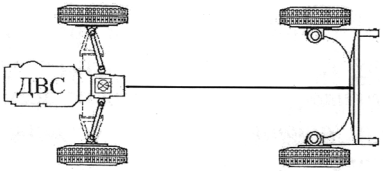
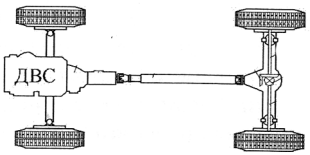
area of their application. Conduct an analysis of each of the given schemes. Conduct a comparative analysis of the layout schemes of cars.

Procedure for completing task #1

The analysis of the layout diagrams should be performed in the form of Table 1.1, 1.2, 1.3.

Table 1.1

Classification of vehicle layout schemes (example)

Classification sign	Type of construction	Models cars
Location driving wheels	1. Front wheel drive, transverse engine 	Lada Granta
	2. Front wheel drive, longitudinal engine 	
	3. Rear wheel drive, front engine 	

End of table. 1.1

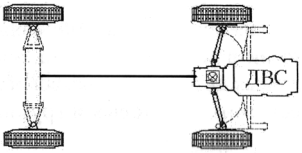
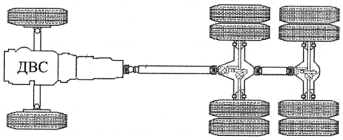
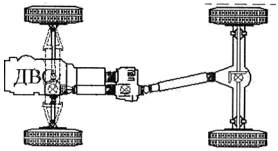
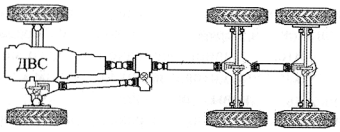
Classification sign	Type of construction	Models cars
	4. Rear wheel drive, rear engine 	
	5. Rear wheel drive 6×4 	
	6. 4x4 all-wheel drive 	
	7. All-wheel drive 6×6 	

Table 1.2

Analysis of mechanical transmission layout schemes

Layout diagram of a mechanical transmission	Advantages	Flaws
Classical		
Front wheel drive		
Rear engine		
Multi-drive		

Table 1.3

Comparative analysis of advantages and disadvantages layout schemes of passenger cars

Parameter being compared	Layout diagram		
	Classical skaya	Front water	Rear wheel drive- naya
Traction properties (empty vehicle)			
Traction properties (laden vehicle)			
Distribution of vehicle weight by axles			
Cabin volume			
Trunk volume			
Possibility of modification of the rear part of the body			
Overall length			
Possibility of creating a four-wheel drive modification			
Noise in the cabin			
Weight			

*Note*When filling in Table 1.4, use the following notations: +++ – good indicator; ++ – satisfactory indicator; + – unsatisfactory indicator.

According to the individual assignment (Table 1.4, Fig. 1.1), draw a kinematic diagram in your workbook. Indicate the units and components designated by numbers that are part of the transmission. Provide examples of the implementation of this diagram.

Table 1.4

Variants of tasks for practical lesson No. 1

Option No.	Layout diagram no. we are in Fig. 1.1	Mass of the transported goods cargo (kg) + passengers- capacity (persons)
1, 7, 13	A	5000 + 2
2, 8, 14	B	7000 + 2

End of table. 1.4

Option No.	Layout diagram no. we are in Fig. 1.1	Mass of the transported goods cargo (kg) + passengers-capacity (persons)
3, 9, 15	IN	9000 + 2
4, 10, 16	G	12,000 + 2
5, 11, 17	D	3500 + 1
6, 12, 18	E	2500 + 1

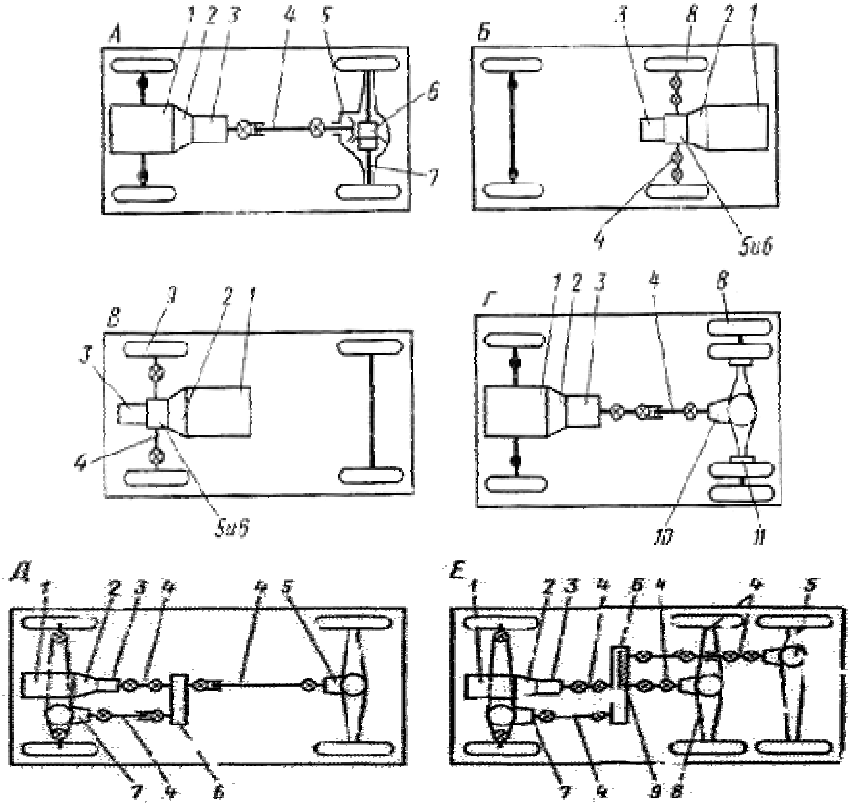


*Fig. 1.1.*Layout diagrams of mechanical transmissions

Task No. 2. Development of a layout scheme truck

Complete an individual assignment to develop a layout diagram of a truck. Each student selects the initial data for calculation and analysis (option number) in accordance with the last digit of their serial number in the group list (see Table 1.4, Fig. 1.1).

Procedure for completing task #2

Based on the purpose of the vehicle, analyze and, if necessary, clarify the initial data for its design, describe the operating conditions and formulate the basic requirements that the vehicle design and its layout must meet.

Before developing a layout diagram, it is necessary to determine the weight of the vehicle and the number of its axles.

Gross vehicle weight m_a is determined by the formula:

$$m_a = m_0 + m_p + m_{gr},$$

Where m_0 – net weight, kg; m_p – the mass of passengers including the driver, $m_p = 75n$ (n – number of passengers, including (dittel); m_{gr} – weight of the transported cargo, kg.

The unladen weight of a vehicle can be determined using the tare coefficient q, which is for a car with a wheel shape The 4x2 and 6x4 mule ranges from 0.6 to 1.4:

$$m_0 = q \cdot m_{gr}.$$

The total weight of the vehicle at its nominal load is determined by the formula

$$G_a = m_a \cdot g,$$

Where m_a – gross vehicle weight, kg; g=9.81 m/s^2 - acceleration due to gravity.

The number of axles of the designed truck is selected based on existing designs, but at the same time, the permissible axle loads are based on the strength of the road surfaces. The permissible axle loads are given in Table 1.5.

Table 1.5

Permissible axial loads, (kN)

Axle type	Road category	
	I and II	Without advanced coatings
Single axle	100	60
2-axle bogie with the distance between axles, m:		
1.0–1.3	160	100
1.3–1.8	180	110
St. 1.8	200	120
3-axle bogie with the distance between axles, m:		
1.0–1.3	210	
1.1–1.8	240	

When determining axle loads, it is necessary to take into account the restrictions that are established for different categories of roads. If the axle load on one or more axles exceeds the established standards, it is necessary to provide for the installation of an additional supporting axle (temporary or permanent) or limit the vehicle's load capacity.

The load on each axle of the vehicle is set based on the fact that

– for two-axle trucks with a cabin behind the wheel gatel

$$G_2 = (0.70–0.75) G_a;$$

– for two-axle trucks with a cab over the engine with a double-wheel drive and a rear axle layout

$$G_2 = (0.65–0.70)G_a;$$

– for two-axle trucks with a cab over the engine with a damper and single wheels on the rear axle

$$G_2 = (0.55–0.60)G_a;$$

– for three-axle trucks with double wheels rear axle forests

$$G_2 - G_3 = (0.75–0.78)G_a;$$

– for three-axle trucks with single wheels rear axle forests

$$G_2 - G_3 = (0.68–0.74)G_a,$$

Where G_1 – weight load on the front axle of the vehicle; G_2 - weight load on the rear axle of a two-axle vehicle and the balance bogie of a three-axle vehicle or the middle axle of a three-axle vehicle with separate suspension of all axles; G_3 – weight load on the rear axle of a three-axle vehicle with separate suspension of all three axles of the vehicle.

Vehicle base L choose based on the existing similar constructions. The coordinates of the center of mass are determined by the expressions:

– for a two-axle vehicle:

$$a = 2\frac{G \cdot L}{G_a};$$

– for a three-axle vehicle:

$$a = \frac{G_2 \cdot L - G_3(L - l)}{G_a},$$

Where l – distance between the middle and rear axles, m.

The distance from the center of mass to the rear axle of the car is determined from the expression:

$$b\text{-}L\text{-}a, \text{ m.}$$

Center of gravity height for trucks

$$h\text{-}(0.9–1.1), \text{ m.}$$

The layout diagram of a truck (Fig. 1.2, 1.3) is developed after selecting and justifying the relative position of the cabin and engine. It is taken into account that for vehicles with wheel arrangements 4x4, 6x6 and 8x8 all wheels are single.

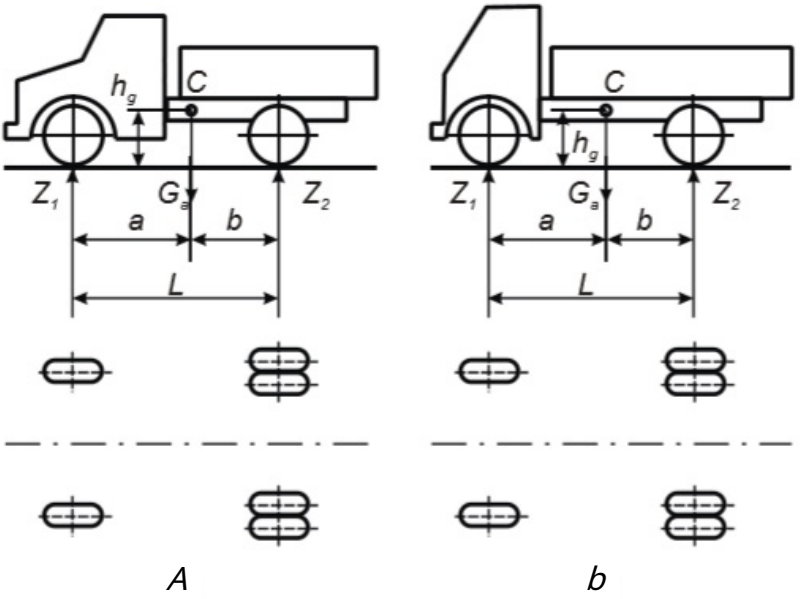


*Fig. 1.2.*Layout diagrams of two-axle vehicles:
A– with a cabin behind the engine;*b*- with a cabin above the engine

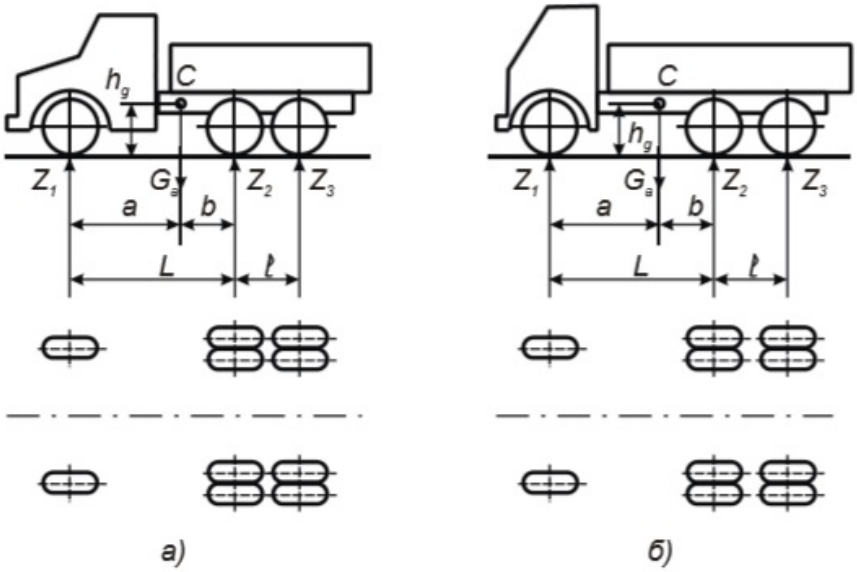


*Fig. 1.3.*Layout diagrams of three-axle vehicles:
A– with a cabin behind the engine;*b*- with a cabin above the engine

3. Contents of the report

In the workbook, in accordance with the option, present to the teacher a kinematic diagram of the car indicating the names of units and assemblies and filled in tables 1.1–1.3, as well as the completed assignment on developing a layout diagram of a truck. Provide a diagram of the car indicating the units and assemblies.

Control questions

1. What types of transmissions are used in cars?
2. Specify the advantages and disadvantages of transmissions with stepped and stepless torque control.

3. List the main requirements
to the transmission of cars.

4. What are the design schemes of mechanical transmissions?
sii with single axle drive are used in cars? What are their main differences?

5. Specify the main advantages and disadvantages of the mechanical transmissions of classical layout; with front axle drive; with rear axle drive.

6. Explain the general structure of mechanical transmissions.
of vehicles with 6×4 wheel arrangement; their advantages and disadvantages.

7. Explain the general structure of mechanical transmissions.
all-wheel drive vehicles, their advantages and disadvantages.

PRACTICAL LESSON #2
ANALYSIS OF CAR CLUTCH DESIGN

Duration of work 4 hours. **Purpose of the work**

To master the skills of analyzing the designs of automobile clutches and to consolidate the skills of performing technical calculations.

1. Basic Provisions

The clutch is intended:

– for smooth disconnection and connection of the engine and vehicle transmission;

– to protect transmission parts from overloads. When analyzing and evaluating clutch designs, as well as other mechanisms, one should be guided by the requirements imposed on them:

– reliable transmission of torque from the engine to the transmission;

– smoothness and completeness of inclusion;

– clean shutdown;

– minimum moment of inertia of driven elements;

– good heat dissipation from friction surfaces;

– protection of the transmission from dynamic loads;

– maintaining the pressing force within specified limits during operation;

– minimal physical effort required for control;

- good balance.

In addition, the clutch, like other mechanisms of the car, is subject to general requirements: ensuring minimum dimensions and weight, simplicity of design and maintenance.

Most modern vehicles are equipped with permanently closed dry single- or double-disk clutches with peripheral arrangement of cylindrical pressure plates.

springs or a centrally located diaphragm spring with forced control.

2. Contents of lesson No. 2

Task No. 1. Analysis of clutch designs

Using [1, 2, 4], develop a classification of the mechanism by its main features and application. Conduct an analysis of existing clutch designs, note the advantages and disadvantages of each of them. Present the classification in the form of a table (example Table 1.1). Fill in Tables 2.2 and 2.3, provide models of cars that have the corresponding clutch type.

Procedure for completing task #1

The analysis of automobile clutches should be carried out in the form of tables indicating examples of the use of one or another type of clutch.

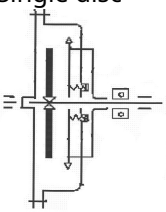
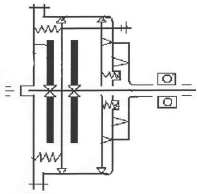
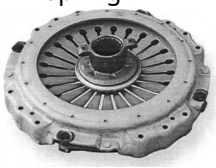
Table 2.1

Analysis of clutch design schemes

Friction		Hydrodynamic		Electromagnetic	
Advantages	Flaws	Advantages	Flaws	Advantages	Flaws
Example of a car with this design clutches		Example of a car with this design clutches		Example of a car with this design clutches	

Table 2.2

Analysis of the design of automotive friction clutches

By number of disks		By type of pressure springs	
Single disc	Double disc	From the periphery-with springs	With diaphragm spring
			

End of table. 2.2

By number of disks		By type of pressure springs	
Models cars	Models cars	Models cars	Models cars

Task No. 2. Calculation exercise

Perform a calculation task to determine the main parameters of the clutch. The variant number is determined in accordance with the last digit of its serial number in the group list (Table 2.3).

Table 2.3

Variants of the calculation task for practical lesson No. 2

No. options	Exercise
1, 6, 11	Determine the safety factor of a single-plate clutch β for the following data: maximum engine torque M_{emax}= 410 Nm; friction coefficient - = 0.25; specific pressure p_0=0.2 MPa; outer diameter of the driven disk D_n= 0.34 m; d_V= 0.185 m
2, 7, 12	Determine the total force of the pressure springs and the specific pressure on the friction linings of a single-disk clutch. Initial data: maximum engine torque M_{emax}= 190 Nm; clutch safety factor - = 1.5; outer diameter of the driven disk D_n= 225 mm; d_V= 150 mm; coefficient of friction -= 0.3
3, 8, 13	Determine the clutch safety factor with a diaphragm spring - , providing force on the pressure plate 3300 N. Initial data: maximum engine torque M_{emax}= 106 Nm; outer diameter of friction linings D_n= 204 mm, inner diameter d_V= 146 mm; coefficient of friction -= 0.3

End of table. 2.3

No. options	Exercise
4, 9, 14	Determine the pressure on the friction linings of a single-disc clutch of a truck. Initial data: max. low engine torque M_{emax}= 290 Nm; clutch reserve factor - = 1.8; outer diameter of friction linings D_n= 300 mm; inner diameter d_V=164 mm; coefficient of friction - = 0.25
5, 10, 15	Determine the pressure on the friction linings of a single-disc clutch of a passenger car, the original old ones: max- low engine torque M_{emax}= 110 Nm; clutch reserve factor - = 1.6; outer diameter of friction linings D_n= 200 mm, inner diameter d_V= 142 mm; coefficient of friction -= 0.3

Procedure for completing task #2 The total pressing force on the friction linings depends on the maximum engine torque M_{emax} and is determined by the formula:

$$P_{\Sigma} = \frac{M_{emax} \cdot \beta}{\mu \cdot i \cdot R_C},$$

where β is the coefficient of adhesion reserve; μ is the coefficient of friction; i – number of friction pairs; R_C – average radius of disks, m.

The number of friction pairs is taken for single-disc clutches – i=2; for double-disc clutches – i=4.

The coefficient of friction depends on a number of factors: parameters of friction materials, condition and relative sliding speed of friction surfaces, pressure, temperature. The calculated coefficient of friction can be taken as: μ = 0.25–0.3.

The pressure on the friction linings depends on the friction area and is determined by the formula

$$p_0 = \frac{R_\Sigma}{F} = \frac{4R_\Sigma}{\pi(D_н^2 - d_в^2)},$$

Where p_0 – pressure on friction linings, Pa; F - square surface area of one side of the friction lining, m^2; $D_н$ And $d_в$ – outer and inner diameters of friction pads doc, respectively.

The calculation tasks should be completed with a detailed description of the sequence of actions to be performed.

3. Contents of the report

In the workbook, in accordance with the option, submit to the teacher the completed analysis of the designs of automobile clutches (Table 2.1, 2.2) and the calculation task in accordance with the option.

Control questions

1. Provide the purpose and classification of the requirement to the clutches.
2. Describe the working process of friction clutches.
3. What design measures ensure reliability? transmission of torque in friction clutches?
4. What constructive measures ensure smoothness and completeness of engagement of friction clutches?
5. What constructive measures ensure the partial-clutch release point?
6. What design measures ensure diversion heat from friction surfaces in friction clutches?

7. What constructive measures ensure pre-protecting the transmission from peak and periodic loads?

8. What constructive measures provide support? maintaining the pressing force within specified limits during operation of friction clutches?

9. What criteria are used to evaluate physical costs? clutch control? Evaluate the different ways to make clutch control easier.

10. List the special types of couplings that are characterized by ize their advantages and disadvantages.

11. Compare the clutch release forces with the central diaphragm spring and with peripherally located springs, if the force of pressure on the driven disk is the same.

12. What is the purpose of the torsion damper springs? fluctuations?

PRACTICAL LESSON #3
ANALYSIS OF CAR CLUTCH DRIVES

Duration of work 4 hours. **Purpose of the work**

To master the skills of analyzing clutch drive designs and performing clutch drive calculations.

1. Basic Provisions

The clutch drive is designed to ensure the disengagement of the clutch, namely the squeezing of the diaphragm spring. Modern cars use the following types of clutch drives: mechanical, hydraulic and electrohydraulic.

The most widely used clutch drives in automobiles are mechanical and hydraulic. The electrohydraulic drive is used to automate clutch control in a robotic gearbox, for example, in the Easytronic gearbox.

Mechanical drive is used as a clutch drive for small passenger cars. This type of drive is distinguished by its simple design and low cost.

The mechanical clutch drive combines the clutch pedal, drive cable and lever transmission. The cable contains a mechanism for adjusting the free travel of the clutch pedal.

The main structural element of the mechanical clutch drive is the cable that connects the clutch pedal to the release fork. The cable is enclosed in a sheath. When the clutch pedal is pressed, the force is transmitted through the cable to the lever transmission, which in turn moves the clutch fork and ensures the clutch release.

The system includes a mechanism for adjusting the free travel of the clutch pedal, which includes an adjusting nut.

ku at the end of the cable. The need for adjustment is due to the gradual change in the position of the clutch pedal due to wear of the friction linings.

The hydraulic clutch drive is similar in design to the hydraulic drive of the brake system. It uses the property of incompressibility of the liquid. Brake fluid is used as the working fluid.

The hydraulic clutch drive has a more complex design. In addition to the pedal, the drive includes the master and slave cylinders, a reservoir of working fluid and connecting pipelines.

Structurally, the master and slave cylinders consist of a piston with a pusher, placed in the housing. When the clutch pedal is pressed, the pusher moves the piston of the master cylinder, the working fluid is cut off from the tank. With further movement of the piston, the working fluid enters the slave cylinder through the pipeline. Under the influence of the liquid, the piston with the pusher moves. The pusher acts on the clutch fork and ensures the clutch is disengaged.

To remove air from the clutch hydraulic system (bleed the system), special valves are installed on the master and slave cylinders (*nipples*).

To make control easier, some car models use a pneumatic or vacuum clutch booster.

Ease of clutch control is ensured by the correct selection of the drive gear ratio to ensure the optimum amount of clutch pedal travel.S_{ped}
and the permissible amount of force on the pedalR_{ped}.

The permissible pedal travel for passenger cars is [S_{ped}] = 160 mm, for cargo – [S_{ped}] = 190 mm. The maximum force on the clutch pedal for passenger cars is [R_{ped}] = 150 Nm, for trucks – [R_{ped}] =250 Nm.

Mechanical drives (Fig. 3.1,*A*) are currently used only on very small class passenger cars. On trucks, buses and small class passenger cars and above, a hydraulic drive is used (Fig. 3.1,*b*).

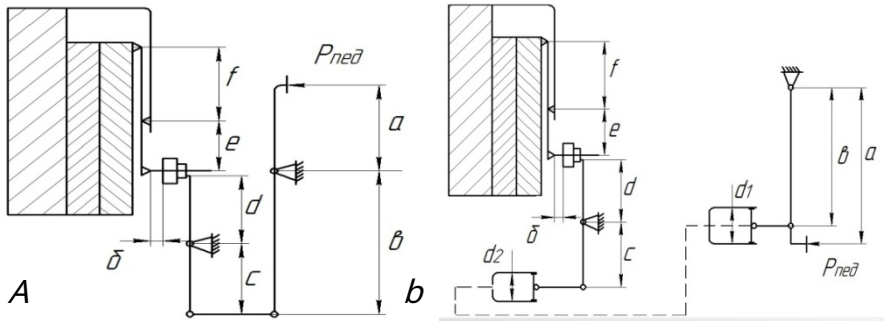


*Fig. 3.1.*Clutch drive diagrams:
A– mechanical drive;*b*- hydraulic drive

When calculating the drive, its gear ratio, pedal force and pedal travel are calculated. In addition, the geometric dimensions of the levers, cylinders and drive rods are determined.

2. Contents of lesson No. 3

Task No. 1. Analysis of clutch drive designs

Using sources [3–5], study the classification and basic requirements for clutch drives. Conduct an analysis of existing clutch drive designs, note the main advantages and disadvantages of each of them. Conduct a comparative analysis of the designs considered.

Procedure for completing task #1

The analysis of the design schemes of clutch drives is presented in the form of Table 3.1.

Table 3.1

Analysis of design schemes of clutch drives

Hydraulic drive clutches		Mechanical drive clutches	
Advantages	Flaws	Advantages	Flaws

Task No. 2. Calculation exercise

Determine the main parameters of the clutch drive using the recommendations, calculation formulas and dependencies set out in [1, 3]. The initial data are given in Table 3.2. The variant number is determined in accordance with the last digit of its serial number in the group list. Draw a kinematic diagram of the calculated clutch drive indicating the obtained geometric parameters.

Table 3.2

Variants of tasks for practical lesson No. 3

Option	Initial data	Drive type
1, 6, 11	*A*=320 mm; *b*=30 mm; *With*= 25 mm; *d*=20 mm; *e* =25 mm; *f*=15 mm. d_1= 12 mm; d_2= 15 mm	Mechanical
2, 7, 12	*A*=300 mm; *b*=25 mm; *With*= 30 mm; *d*=25 mm; *e* =25 mm; *f*=20 mm; d_1= 12 mm; d_2= 15 mm	Mechanical
3, 8, 13	*A*=320 mm; *b*=30 mm; *With*= 30 mm; *d*=25 mm; *e* =25 mm; *f*=15 mm; d_1= 18 mm; d_2= 18 mm	Hydraulic-sky
4, 9, 14	*A*=310 mm; *b*=20 mm; *With*= 20 mm; *d*=20 mm; *e* =25 mm; *f*=18 mm; d_1= 15 mm; d_2= 15 mm	Mechanical
5, 10, 15	*A*=320 mm; *b*=25 mm; *With*= 20 mm; *d*=20 mm; *e* =25 mm; *f*=15 mm; d_1= 12 mm; d_2= 12 mm	Hydraulic-sky

Procedure for completing task No. 2.

Overall gear ratio of the clutch drive with peripheral springs i_{pr} includes pedal gear ratio

clutches i_{ped}, clutch release fork ratio

nia i_V, hydraulic drive ratio i_G and the gear ratio of the clutch release levers i_r.

$$i_{pr} = i_{ped} i_V i_G i_r = \frac{a}{b} \frac{c}{d} \left(\frac{d_2}{d_1}\right)^2 \frac{e}{f},$$

Where a And b – pedal shoulders; c And d – shoulders of the switch fork; d_1 And d_2 – diameters of the actuator and main cylinders of the hydraulic drive; e And f – clutch release lever shoulders.

Overall gear ratio of the clutch drive with diaphragm spring i_{pr} includes the gear ratio of the petals diaphragm spring i_f, clutch release fork ratio i_V, gear ratio of hydraulic drive i_G and clutch pedal ratio i_{ped}:

$$i_{pr} = i_{ped} i_V i_G i_f = \frac{a}{b} \frac{c}{d} \left(\frac{d_2}{d_1}\right)^2 \frac{e}{f},$$

Where a And b – pedal shoulders; c And d – shoulders of the switch fork; d_1 And d_2 – diameters of the actuator and main cylinders of the hydraulic drive; e And f – clutch release lever shoulders (petals) diaphragm spring coils).

The gear ratio of the diaphragm spring can be determined by the formula

$$i_f = \frac{e}{f} = \frac{D_C - D_i}{D_e - D_{WITH}}$$

For modern drive designs, the overall gear ratio is i_{pr} = 25–45 and must provide a pedal force of no more than 150 N for passenger cars and no more than 250 Nm for trucks. If the pedal force exceeds the specified values, the clutch drive must be equipped with a booster.

Existing drive designs usually have the following gear ratio values: i_r = 3.8–5.5; i_N = 1.4–2.2

[5]. In calculations, the values of gear ratios are usually specified. i_{pr}, i_r, i_N, then find the clutch pedal gear ratio leniya i_{ped}.

Next, the calculated force on the pedal and the full travel of the clutch pedal are determined and the conditions are checked:

$$P_{ped} \leq P_{ped}; \quad S_{ped} \leq S_{ped}.$$

The maximum force on the clutch pedal with booster must not exceed [P_{ped}] = 150 N; clutch with booster [P_{ped}] = 250 N. Permissible pedal travel for passenger cars [S_{ped}] = 160 mm, for cargo [S_{ped}] = 190 mm.

The pedal force is determined by the formula:

$$P_{ped} = \frac{R_{\Sigma max}}{i_{pr} i_p \eta_{pr}}$$

Where R_{ped} – pedal force, N; η_{pr} – Clutch drive efficiency, for mechanical drive η_{pr} = 0.7–0.8; for hydraulic drive η_{pr} = 0.8–0.9.

The full travel of the mechanical drive pedal consists of the free travel of the pedal, the working travel and the elastic deformations of the drive elements. The full travel of the hydraulic drive pedal is calculated using the formula

$$S_{ped} = S_{sv} + \frac{\delta + i_{np} \Delta S}{i_r} i_{pr},$$

Where S_{ped} – full travel of the clutch pedal, m; S_{sv} – free pedal travel, m; S_r – working stroke of the pedal, m; δ – clearance in the release mechanism (between the clutch and the release levers), m; ΔS – stroke of the pressure plate, m; i_r – gear ratio of the release levers.

Gap size in the release mechanism [2]:

– for couplings with peripheral cylindrical springs gins – δ = 1.5–2.0 mm;

– for clutches with a central diaphragm spring noy – δ = 3.5–4.0 mm.

Pressure plate stroke [5]:

– for single-disc clutches – Δ*S*=1.5–2.0 mm;

– for double-disc clutches – Δ*S*=2.4–2.8 mm.

3. Contents of the report

In the workbook, in accordance with the option, submit to the teacher the analysis of the clutch drives in Table 3.1. Draw up the calculation task with a detailed description of the sequence of actions. Draw a kinematic diagram of the calculated clutch drive indicating the obtained geometric parameters.

Control questions

1. Name the main advantages and disadvantages of mechanical clutch drive.

2. What conditions determine the gear ratio? clutch drive?

3. Draw a diagram of the mechanical clutch drive and Write down an expression to determine its overall gear ratio.

4. Draw a diagram of the hydraulic clutch drive and Write down an expression to determine its overall gear ratio.

5. How is the hydraulic transmission ratio determined? clutch drive?

6. How is the clutch drive gear ratio determined? with a diaphragm spring?

7. How do the dimensions of the diaphragm spring affect the trans- clutch drive date number?

PRACTICAL WORK #4 ANALYSIS OF GEARBOX DESIGN CARS

Duration of work 4 hours. **Purpose of the work**

To master the skills of analyzing gearbox designs and performing calculations of gear transmissions.

1. Basic Provisions

The gearbox is designed:

– for maximum use of engine power damper or to ensure minimum fuel consumption under any driving conditions (by changing the moment of resistance at the engine inlet);

– for long-term separation of the engine from the transmission;

– to ensure reversibility of movement (movement in reverse).

The following requirements apply to the gearbox:

– ensuring optimal traction, speed and fuel-but-economic properties of the car with a given external characteristic of the engine;

– noiseless operation and gear shifting;

– ease of control;

– high efficiency.

In addition, the gearbox, like all other mechanisms of the car, is subject to such general requirements as ensuring optimal dimensions and weight, simplicity of design and maintenance, manufacturability, maintainability, and low noise levels.

When analyzing the design of gearboxes, as well as other mechanisms, one should be guided by the requirements imposed on them, which, in general, are determined by the purpose.

2. Contents of lesson No. 4

Task No. 1. Analysis of gearbox designs

Using sources [3–5], study the classification and basic requirements for gearboxes, area of application.

Conduct an analysis of existing designs of mechanical gearboxes, note the main advantages and disadvantages of each of them. Make a comparative analysis of the designs considered.

Procedure for completing task #1

The classification of gearbox designs is presented in the form of a table (example Table 1.1). The results of the analysis of gearbox design diagrams are presented in the form of Table 4.1. In accordance with the individual assignment (Table 4.2), study the gearbox diagram, operating principle and area of application.

Table 4.1

Analysis of design schemes of mechanical gearboxes

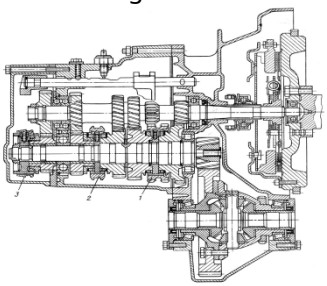
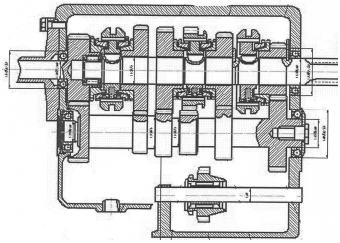
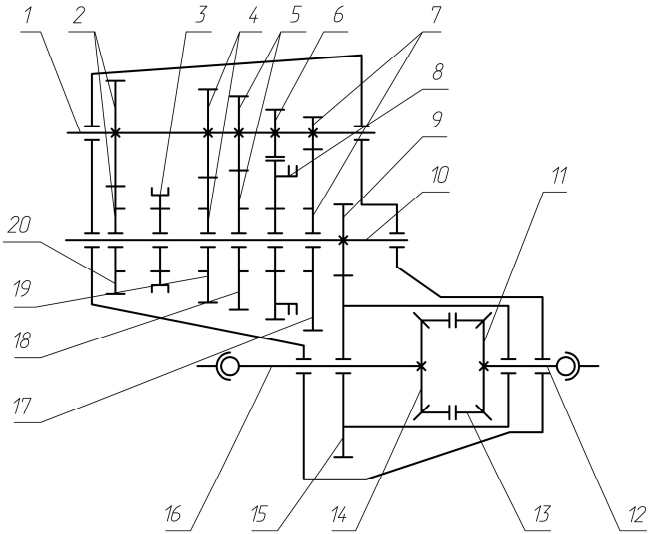
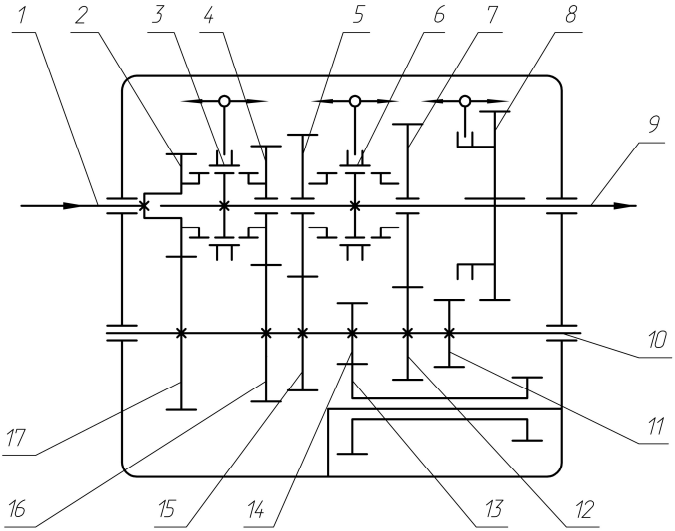
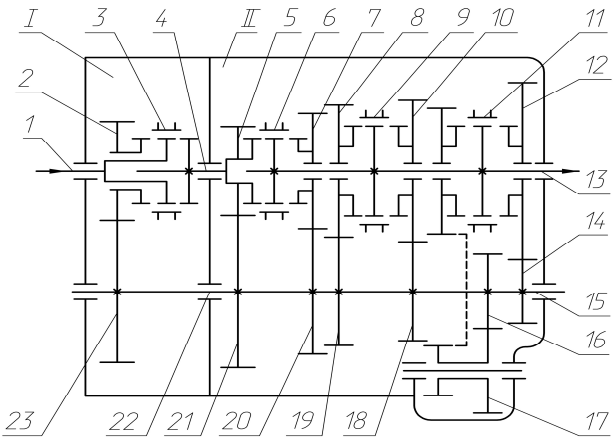
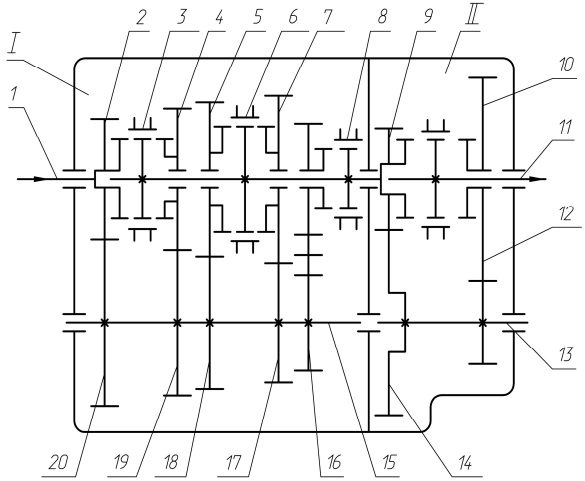
<table>
<tr><td colspan="2">Twin shaft gearboxes
  </td><td colspan="2">Three-shaft gearboxes
  </td></tr>
<tr><td colspan="2">Examples</td><td colspan="2">Examples</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Advantages</td><td>Flaws</td><td>Advantages</td><td>Flaws</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Table 4.2

Variants of tasks for practical lesson No. 4

Option	Gearbox diagram
1–4	
5–8	

End of table. 4.2

Option	Gearbox diagram
9–12	
10–14	

Task No. 2. Calculation exercise

In accordance with the assignment (Table 4.2), complete the calculation exercises using the recommendations, calculation formulas and dependencies set out in [1, 3].

According to the task (Table 4.3), draw a diagram of the gearbox and number all the gear wheels. On the diagram, indicate all the elements that make up the unit under consideration. Analyze the sequential nature of the change in gear ratios and torque (power flow) when it is transmitted from the engine to the drive axles through the corresponding gear wheels for each of the gears.

Table 4.3

Variants of tasks for practical lesson No. 4

Option	Initial data
1, 6, 11	Determine the forces acting on the gear teeth of a three-shaft gearbox of a passenger car. Initial data: maximum engine torque - 90 Nm; clutch safety factor - 1.6; vehicle adhesion weight - 7400 N; wheel radius - 0.28 m; intermediate shaft drive gear parameters: number of teeth - 17 and 29, tooth inclination - 31°; first gear - 15 and 33, 27°; second gear - 20 and 27, 29°; third gear - 24 and 21, 31°; tooth module of all gears - 2.5 mm; gear ratio of the intermediate shaft - 4.3
2, 7, 12	Approximately determine the center distance and shaft diameters of a three-shaft gearbox of a passenger car with a maximum engine torque of 110 Nm and a first gear ratio of 3.7; as well as for a truck with an engine torque of 410 Nm and a first gear ratio of 7.44
3, 8, 13	Calculate the rigidity of the secondary shaft of the gearbox of a truck based on the deflection in the vertical and horizontal planes, as well as the total deflection. Initial data: maximum engine torque - 400 Nm; number of teeth: intermediate shaft drive - 20 and 43, first gear - 13 and 45, second gear - 22 and 42; inclination of the teeth of the second gear and intermediate shaft drive gears - 25°; tooth module: first gear - 4.25 mm, second gear - 3.5 mm; distances from supports: first gear gears - 250 and 90 mm, second gear - 210 and 130 mm; calculated diameter of the secondary shaft - 58 mm

End of table. 4.3

Option	Initial data
4, 9, 14	Based on the initial data of the previous problem, determine the angle of skew of the second gear gear relative to the vertical and horizontal axes of the secondary shaft when transmitting maximum torque, and also calculate the secondary shaft for static strength based on the total bending and torsional stress.
5, 10, 15	Determine the angle of twist of the secondary shaft of the gearbox of a passenger car in direct and first gear. Initial data: maximum engine torque - 190 Nm; calculated shaft diameter - 30 mm; shaft length, respectively, - 760 and 420 mm

Procedure for completing task No. 2.

When performing calculations, use the methods given in [1, 3].

3. Contents of the report

In the workbook, in accordance with the option, present to the teacher the classification of gearboxes in the form of a table (example Table 4.1); analysis of the designs of mechanical gearboxes in Table 4.1. Design the calculation task with a detailed description of the sequence of actions. Draw a diagram of the gearbox with a specification.

Control questions

1. List the requirements for gearboxes.
2. Provide a classification of gearboxes.
3. List the evaluation parameters of gearboxes (row density, number of gears, etc.).
4. List the advantages and disadvantages of twin-shaft gearboxes.

5. List the advantages and disadvantages of three-shaft gearboxes.

6. List the advantages and disadvantages of multi-shaft gearboxes.

7. Analyze the methods of engaging gears.

8. Synchronizers (purpose, design, principle works).

9. Why are two-wheel drives not used on trucks? shaft stepped gearboxes?

10. What should be the direction of the bevel of the teeth on the gear? on the intermediate shaft of the gearbox to balance the axial forces?

PRACTICAL LESSON #5
ANALYSIS OF STEERING GEAR DESIGN CARS

Duration of work 4 hours. **Purpose of the work**

To study the purpose, classification, design, operation of automobile steering systems, as well as the requirements imposed on them. To determine the main technical parameters, kinematic and force connections necessary for the analysis of steering control designs.

1. Basic Provisions

The steering system includes the steering mechanism, the steering drive, in some vehicles the power steering is a device that largely ensures driving safety, as a result of which high demands are placed on it:

– the smallest possible value of the minimum radius gates to ensure good maneuverability of the vehicle;

– low steering effort, ensuring easy control bone;

– force and kinematic tracking action, i.e. pro-proportionality between the force on the steering wheel and the moment of resistance to turning of the steered wheels and a given correspondence between the angle of rotation of the steering wheel and the angle of rotation of the steered wheels;

– minimal lateral wheel slip when turning;

– minimal transmission of shocks to the steering wheel from an impact;

– control of wheels on uneven roads;

– elastic optimal steering characteristic ion, which determines its sensitivity and eliminates the possibility of the occurrence of self-oscillations of the steered wheels;

- kinematic coordination of steering elements control with suspension to prevent spontaneous rotation of the steered wheels when the elastic elements are deformed;

– minimal impact on the stabilization of the steered wheels;

– increased reliability, since failure of the steering

The failure of the control leads to an accident.

In addition, the steering, like all other mechanisms of the car, is subject to the following general requirements: ensuring optimal dimensions and weight, simplicity of design and maintenance, manufacturability, maintainability, etc.

The steering gear is a reduction gear that converts the rotation of the steering wheel shaft into the rotation of the pitman arm shaft. The mechanism allows the driver to increase the force applied to the steering wheel. The increase in force occurs due to the gear ratio of the steering gear.

Steering mechanisms are divided into worm, screw, crank, toothed and combined. Common steering mechanisms include "worm-roller", "worm-sector", "pinion-rack", "screw-rack-pinion".

The steering gear is designed to transmit force from the steering mechanism to the steered wheels. Mechanical steering gears are the most common. The design of the steering gear depends on the type of front suspension. The steering gear includes a steering trapezoid formed by transverse steering rods, steering knuckle levers and the axle of the steered wheels.

2. Contents of lesson No. 5

Task No. 1. Analysis of design schemes steering controls

Using sources [2, 4, 6], study the classification and basic requirements for steering mechanisms, the area of application. Perform an analysis of existing design schemes of steering mechanisms, note the main advantages and disadvantages.

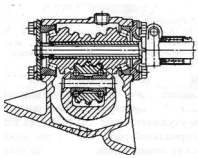
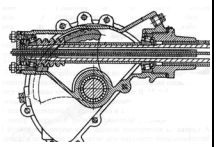
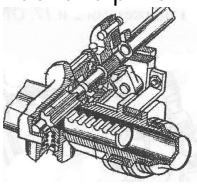
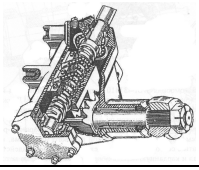
the results of each of them. Make a comparative analysis of the considered designs.

Procedure for completing task #1

The classification of steering mechanism designs shall be presented in the form of a table (example Table 1.1). The results of the analysis of the design schemes of steering mechanisms shall be presented in the form of Table 5.1.

Table 5.1

Table Header

Steering mechanism type							
"worm roller" 		"worm sector" 		"rack and pinion" 		"screw-gear-rail" 	
Example		Example		Example		Example	
Worthy-sva	Not enough tatki	Worthy-sva	Not enough tatki	Worthy-sva	Not enough tatki	Worthy Instva	Not enough tatki

Task No. 2. Calculation exercise

In accordance with the individual assignment (Table 5.2) and using the recommendations, calculation formulas and dependencies set out in [2, 6], determine the force applied by the driver to the steering wheel. Assess the feasibility of installing a booster.

Table 5.2

Variants of tasks for practical lesson No. 5

Option	Initial data
1, 6, 11	m_A=5.0 t; λ_1= 0.4; r_{sh}= 0.25 MPa; μ = 0.8; R_p=200 mm; - =0.8; u_r=21

End of table. 5.2

Option	Initial data
2, 7, 12	m_A=5.5 t; λ_1= 0.4; r_{sh}= 0.25 MPa; μ = 0.8; R_p=200 mm; - =0.8; u_r=21
3, 8, 13	m_A=6.0 t; λ_1= 0 , 4; r_{sh}= 0.25 MPa; μ = 0.8; R_p=200 mm; - =0.8; u_r=21
4, 9, 14	m_A=6.5 t; λ_1= 0.4; r_{sh}= 0 , 25 MPa; μ = 0.8; R_p=200 mm; - =0.8; u_r=21
5, 10, 15	m_A= 7.0 t; λ_1= 0.4; r_{sh}= 0.25 MPa; μ = 0.8; R_p=200 mm; - =0.8; u_r=21

Procedure for completing task #2

Effort on the steering wheel is regulated GOST 21398–75 and when switching from straight-line movement to movement in a circle with a radius of 12 m at a speed of 10 km/h on a horizontal section with a dry hard surface should not exceed [F_p] = 250 N for non-power-assisted steering and [F_p] = 120 N for power steering.

The force on the steering wheel rim is determined using the relationship

$$F_p = \frac{M_\Sigma}{R_p u_r \eta},$$

Where M_Σ – total moment on the trunnions of the steering wheels; R_p - steering wheel radius; And_r – steering gear ratio nism; - – steering efficiency.

M_Σ on the trunnions of the steering wheels, the semi-empiric dependence

$$M_\Sigma = 10^{-3} \frac{\mu}{3} \sqrt{\frac{G_1^3}{p_{sh}}},$$

Where G_1 – the weight of the vehicle falling on the drive wheels of the vehicle car; μ – coefficient of friction of the tire on the road; r_{sh} – tire pressure.

Based on the calculations, a conclusion is made about the advisability of installing an amplifier.

3. Contents of the report

In the workbook, in accordance with the option, present to the teacher the classification in the form of a table (example table 1.1); perform the analysis of the steering mechanism designs in the form of table 5.2. Design the calculation task with a detailed description of the sequence of actions.

Control questions

1. What are the main technical parameters of the steering wheel? management.
2. Purpose, design requirements and classification steering mechanisms.
3. Name the parameter for evaluating the steering mechanism.
4. Compare steering mechanisms of different types in terms of efficiency.
5. For what purpose are steering mechanisms with gear shifts used? belt gear ratio?
6. Why is backlash-free engagement necessary? the steering gear in the middle position when the car is moving straight ahead?
7. Main technical parameters of the steering drive.
8. What is meant by angular compliance of the steering control, and how does it affect the car's handling?
9. Purpose, design requirements and classification power steering of cars.
10. What constructive measures can be used to limit to reduce the transmission of shocks from road bumps to the steering wheel?
11. How is the power and kinematics provided? what is the power steering tracking action?

PRACTICAL LESSON #6 ANALYSIS OF CARDAN DRIVE DESIGN CARS

Duration of work 4 hours. **Purpose of the work**

To study the classification and design of cardan transmissions. To acquire skills in calculating cardan transmissions of unequal angular velocities.

1. Basic Provisions

A cardan transmission is a transmission that provides power connection between the mechanisms of a vehicle, the shafts of which are not aligned or are located at an angle and serve to transmit torque between the shafts of the mechanisms, and their relative position can change during the movement of the vehicle as a result of elastic deformation of the frame or body.

Depending on the type, layout and design of the vehicle, the cardan transmission can transmit torque from the gearbox to the transfer case or to the final drive of the drive axle, from the transfer case to the final drives of the drive axles, between the final drives of the middle and rear drive axles, from the half-shafts to the front drive and steering wheels, from the final drive to the drive wheels with independent suspension. The cardan transmission can also be used in the drive from the power take-off to the auxiliary mechanisms and to connect the steering wheel with the steering mechanism.

The main element of cardan transmissions are joints and shafts. Cardan joints are divided into joints of unequal (asynchronous) angular velocities and joints of equal (synchronous) angular velocities. Cardan transmissions of various types are used to connect the mechanisms of a car.

In addition to the general requirements (minimum dimensions and weight, simplicity of design and maintenance, manufacturability,

suitability for installation, etc.) special requirements are imposed on the cardan transmission:

– ensuring equality of angular velocities of the leading and the leading of the shafts regardless of the angle between the connected shafts;

– transmission of torque without creation in the transmission vehicle additional loads (bending, torsional, axial, vibration);

– high efficiency;
– silent operation;
– reliability and durability of the structure.

2. Contents of lesson No. 6

Task No. 1. Analysis of design schemes of cardan transmissions

Using sources [1, 2, 4], study the classification, scope of application and basic requirements for cardan gear designs. Analyze existing designs, note the main advantages and disadvantages of each. Analyze equal and unequal velocity joints. Present the classification of cardan gears in the form of a table (example Table 1.1).

Procedure for completing task #1

The classification of cardan transmissions is presented in the form of a table (example Table 1.1). The analysis of cardan transmission designs is presented in the form of Tables 6.1, 6.2.

Table 6.1

Analysis of cardan transmission designs unequal angular velocities

Wheel arrangement	Number of shafts of the car- of this program	Number of cardan shafts hinges	Connectable units transmissions
4×2 			

End of table. 6.1

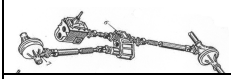
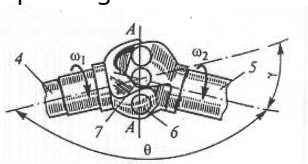
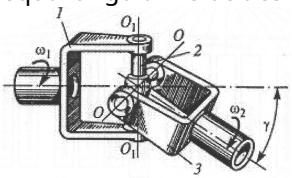
Wheel arrangement	Number of shafts of the car- of this program	Number of cardan shafts hinges	Connectable units transmissions
4×4 			
6×4			
6×6 			

Table 6.2

Analysis of cardan joint designs

Cardan joint equal angular velocities 		Cardan joint unequal angular velocities 	
Advantages	Flaws	Advantages	Flaws

Task No. 2. Calculation exercise

In accordance with the individual assignment (Table 6.3), determine the critical rotation frequency of the cardan shaft, calculate the strength of the cardan joint crosspiece with and without lubrication in the splines.

Table 6.3

Variants of tasks for practical lesson No. 6

Option	Initial data for calculation
1, 6, 11	L =1164 mm; d=71 mm; δ = 1.8 mm; d_{sh}= 12.23 mm; H=72.2 mm
2, 7, 12	L =790 mm; d=66 mm; δ = 2.0 mm; d_{sh}= 14.73 mm; H=51.17 mm

End of table. 6.3

Option	Initial data for calculation
3, 8, 13	L =958 mm; d=35 mm; δ = 2.5 mm; d_{sh}= 16.3 mm; H=80.0 mm
4, 9, 14	L =1300 mm; d=71 mm; δ = 2.1 mm; d_{sh}= 22.0 mm; H=90.0 mm
5, 10, 15	L =1430 mm; d=71 mm; δ = 3.0 mm; d_{sh}= 25.0mm; H=108 mm

Procedure for completing task #2

When performing the task, use the methodology, calculation formulas and dependencies set out in [1, 3]. The following designations are used in Table 6.3: length of the large shaft L, mm; inner diameter of the shaft d, mm; shaft wall thickness δ, mm; crosspiece pin diameter d_{sh}, mm; distance between ends of spikes H, mm.

We accept the length of the crosspiece tenon $l_{sh}=d_{sh}$, average radius of application of lateral force to the spike R=0.5(H-d_{sh}), average radius of spline engagement of the coupling r=0.5R, the angle between the axes of the shafts α = 0°; the coefficient of friction in the splined connection with lubrication is taken to be μ = 0.05, without lubrication – μ = 0.3.

3. Contents of the report

In the workbook, in accordance with the option, present to the teacher the classification of cardan transmissions; analysis of the designs of cardan transmissions in Tables 6.2, 6.3. Design the calculation task with a detailed description of the sequence of actions.

Control questions

1. Formulate the purpose of cardan gears, according to By what design features are they classified?

2. What are the design features of the cardan shaft? equal and unequal angular velocity transmissions?

3. How is the selection of the main parameters of the cardan shaft made?
transmission?

4. What is the critical shaft speed and how
is it determined?

5. How is the shear stress of the crosspiece tenons determined?

6. How is the bending stress of the crosspiece tenons determined?

7. How is axial friction force determined?

8. How is the additional load from the
axial friction force?

9. On the tension of which units and parts (in addition to the fasteners) (stovina) are affected by axial friction forces in a splined coupling?

PRACTICAL LESSON #7 ANALYSIS OF BRAKE SYSTEM DESIGN CARS

Duration of work 4 hours. **Purpose of the work**

Acquisition of skills in analyzing the design of vehicle braking systems and skills in calculating braking systems.

1. Basic Provisions

In order to avoid an emergency, the operation of the car is allowed if the braking system is in good working order. This system on the car is necessary to reduce its speed and stop, as well as to hold it in place. To ensure maximum traffic safety, modern cars are equipped with several braking systems, each performing its own purpose.

Types of braking systems:

- working;
- parking;
- spare;
- auxiliary.

*Service brake system*allows the driver in normal conditions operating conditions to reduce the speed of the vehicle until it stops completely. This system is activated by the force of the driver's foot, which he applies by pressing the foot brake pedal. Compared to other types of braking systems, the working system has the highest efficiency.

*Parking brake system*is designed to hold holding the car in place when it is parked. It is also used to keep the car from rolling backwards if it starts moving on an incline. The parking brake system is controlled by the driver's hand through the handbrake lever.

Spare brake system serves to stop the car vehicle in the event of failure of the working braking system. It has a less effective braking effect on the vehicle than the working system. The functions of the spare braking system can be performed by the parking system.

Auxiliary braking system used in ka- as a retarder, mainly on heavy-duty vehicles. It is used to reduce the load on the service brake system during prolonged braking, for example on a long descent.

There are the following types of brake mechanisms:

– friction (mechanical);

- disk;
- drum;

– hydraulic;

- electric;
- shoe;
- transmission;
- wheeled;
- tape.

Friction brake mechanisms are most often used. For passenger cars, disc brake mechanisms are most often used on the front wheels, and drum shoe brake mechanisms on the rear wheels. Drum shoe brake mechanisms are also installed on trucks.

The advantages of disc brakes are a high coefficient of braking efficiency, small weight and dimensions, low temperature of the brake fluid, reliability. The disadvantages of disc brakes are a low level of dirt protection.

The advantages of drum brakes are greater braking force, durability, and low cost. The disadvantages of drum brakes include slow action and sticking of the brake pads.

2. Contents of lesson No. 7

Task No. 1. Analysis of brake system designs

Using sources [2, 4], study the classification and basic requirements for braking systems, the area of application. Conduct an analysis of existing designs of braking systems, note the main advantages and disadvantages of each of them. Perform a comparative analysis of designs. The task options are given in Table 7.1.

Table 7.1

Task options

Option	Car brand
1, 5, 9, 13	KAMAZ-5320; VAZ-2131
2, 6, 10, 14	VAZ-2107; MAZ-6422
3, 7, 11, 15	PAZ-4234; Ural-4320
4, 8, 12, 16	GAZ-3221; ZIL-4331

Procedure for completing task #1

The classification of braking systems is presented in the form of a table (example Table 1.1). The results of the analysis of the design schemes of braking systems are presented in the form of Table 7.2.

Table 7.2

Analysis of the design of vehicle braking systems

Brand auto-mobile	Characteristics-ka brake mechanism front wheels	Characteristics-ka brake mechanism rear wheels	Characteristics-ka drive working brake systems	Characteristics-ka drive parking brake systems

Task No. 2. Calculation exercise

In accordance with the individual assignment (Table 7.2), complete calculation exercises to determine the parameters of vehicle braking systems.

Table 7.2

Individual tasks

Option	Initial data
1, 5, 9, 13	Determine the total braking torque on all wheels of the vehicle based on the wheel-road adhesion condition and the specific load on the brake linings during braking according to the data in Table 7.2.
2, 6, 10, 14	Determine the total braking torque on all wheels of a car at a given intensity j=5 m/s$_2$specific work of friction of brake mechanisms until complete stop from a speed of 40 km/h according to the data in Table 7.3
3, 7, 11, 15	Calculate the pressure in the hydraulic brake drive of a passenger car, required to ensure maximum braking torque on the front wheels. Data for calculation: coefficient of adhesion - = 0.7; vehicle base L=2.8 m; coordinates of the center of mass α = 1.35 m; h=0.5 m; wheel radius r_{To}= 0.31 m; friction coefficient μ = 0.35, other parameters are given in Table 7.2 and Fig. 7.1
4, 8, 12, 16	Determine the braking torque and heating of the rear drum brake mechanisms at a fluid pressure of ρ = 8 MPa. Data in Table 7.2, mass redistribution coefficient m_2= 0.82, brake drum weight 4.5 kg

Procedure for completing task #2

The calculation of braking control begins with determining the total braking torque of all wheels of the car for a given intensity or for the adhesion of the wheel to the road. Then, taking into account the coefficient of redistribution of the mass of the car during braking, the maximum braking torque on the front and rear axles is calculated. The type of brake mechanism and its main dimensions are selected. On the correct choice of geo-

Metric dimensions can be judged by the specific friction work and heating of the brake mechanism.

The calculated braking moment is used to determine the drive forces of the expansion device and the reactions of the shoe supports. The strength calculation of the brake mechanism is reduced to calculating the support pins for shear and crushing, the shaft of the expansion cam for torsion, the drum for rupture resistance in the diametrical section, the lower and upper ends of the shoes for crushing. The shoes are calculated for bending and rigidity, the pipelines - for rupture with a reserve of about 2, the pedal - for bending.

The parameters of the brake mechanisms are given in Table 7.3. The design diagram of the brake mechanism is shown in Fig. 7.1.

Table 7.3

Parameters of brake mechanisms

Brake parameters mechanism	Initial data	
	front	rear
$r_{b,}$cm	14	14
a_k, cm	10.7	10.7
$With_k$, cm	10.5	10.5
b_k, cm	4.8	4.8
β_1, °	120	102
β_2, °	120	102
d_1	32	32

The total braking moment of all wheels of the vehicle is determined by:

– according to the specified braking intensity (to ensure (security requirements):

$$T\text{-}m_a\gamma r_{To},$$

Where -=(1.3–1.5)-n; -n– standard deceleration (5.5–5.8 m/s).

– for wheel adhesion to the road (for strength calculation):

$$T\text{-}m_a g r_{To}.$$

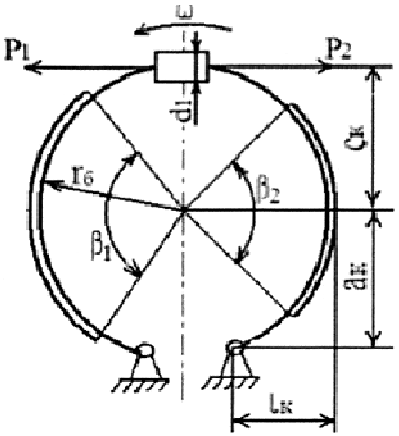


*Fig. 7.1.*Calculation scheme of the brake mechanism

Maximum braking moments on the front and rear wheels:

$$T_{\tau 1} = \frac{m_a g}{2L}(b - h\varphi_0)r\varphi_{To}$$

$$T_{\tau 2} = \frac{m_a g}{2L}(b - h\varphi_0)r\varphi_{To}$$

Here m_a – gross vehicle weight, kg; L, h, A, b - base, height center of mass, distance from the front axle to the center of mass and from the center of mass to the rear axle of the vehicle, m; r_{To} – wheel radius, m;

φ_0 and φ are the coefficients of adhesion, the optimal $\varphi_0 = 0.45$ and maximum $\varphi = 0.8$.

Braking torque of a shoe mechanism with one-sided support arrangement:

$$T_{\tau} = \mu r_b (a_k - c_k)\left(\frac{P_1}{a_k - \mu l_k} - \frac{P_2}{a_k - \mu l_k}\right),$$

where μ is the coefficient of friction; r_b – radius of the friction surface drum, m; a_k, c_k, l_k – geometric parameters of the brake mechanism; P_1, P_2 – drive forces on the primary and secondary pads.

For a drum brake mechanism with a pneumatic drive, the ratio of the expansion forces is determined by the expression:

$$P_2 = \frac{P_1(a_k + \mu l_k)}{a_k - \mu l_k}.$$

Specific load on brake linings:

$$p = \frac{m_a g}{F} = p,$$

Where F – total surface area of friction linings.

For the shoe brake lining:

$$F_k = 0,0175 b_k r_b \beta_b,$$

Where , – width of the overlay; β_b – angle of coverage of the pad.

Recommended values for drum brake $[p]$ = = 0.2–0.3 MPa; for disk $[p]$ = 0.5–0.35 MPa; β_b = 90–120°.

For disc brake lining:

$$F_k = \frac{\pi d}{360}(r_n^2 - r_v^2)$$

Where r_n And r_v – outer and inner radii of the shoe.

Specific friction work of all linings during braking to a complete stop:

$$L = \frac{m_a v_a^2}{26.9 F} = L,$$

Where v_a – initial braking speed, km/h.

Recommended values L = 800–900 J/cm^2.

Heating of the brake drum during single and short-term braking:

$$\Delta T = \frac{m_a v^2 0.922}{z C m_b 10^5},$$

Where z – number of brake drums; $WITH$ – heat capacity of the drum (for cast iron 500 J/kg deg., aluminum – 840 J/kg deg.); m_b - drum weight, kg.

Diameter of the main brake cylinder of the hydraulic drive:

$$d_G = \sqrt{\frac{4 P_n \eta U_n}{\pi p_\tau}}.$$

Diameter of the main working cylinder of the hydraulic drive:

$$d_T = \sqrt{\frac{4 P_1}{\pi p_\tau}}.$$

Here P_p – pedal force; η – hydraulic drive efficiency; U_n - re- pedal date number; p_τ – maximum pressure in the main line; P_1 – the force of attraction of the pads to the drum, N.

Recommended values P_n=500–700 N; η = 0.85–0.9; U_n=4–6; p_τ= 8–10 MPa.

Air pressure in the brake chamber to create the expansion force P_1 And P_2, providing the necessary torque brain moment:

$$p_N = \frac{(P_1 P) h_2}{F_d l \eta},$$

Where P_1, P_2 – expansion forces; h – shoulder of expanding forces; F_d - effective area of the brake chamber; l - application shoulder

forces on the brake chamber rod; η – efficiency of the brake mechanism drive, η = 0.95.

3. Contents of the report

In the workbook, in accordance with the option, present to the teacher the classification of braking systems; analysis of the designs of braking systems in Table 7.1. Design the calculation task with a detailed description of the sequence of actions.

Control questions

1. List the types of vehicle braking tailor's means.
2. Provide a structural diagram of the brake control modern car.
3. Provide a structural diagram of the brake system of a car. car.
4. Provide a structural diagram of the brake drive of the car. car.
5. List the modern requirements for brakes car control.
6. Provide a brake diagram for emergency braking. vehicle, indicate the characteristic points.
7. What does the magnitude of maximum deceleration depend on? car when braking?
8. What factors determine the length of the braking distance?
9. How does wheel slip affect the stability of movement? car?
10. Explain the purpose of brake force regulators?
11. Formulate the purpose of ABS?
12. List the main elements of ABS.
13. Provide diagrams of the use of ABS in a car.

14. What criteria are used to evaluate brake mecha-
lows?

15. Compare the different types of brake mechanisms.

16. Provide diagrams of dual-circuit brake hydraulic systems.
drives and compare them with each other.

17. How is the tracking action of the amplifier ensured?
brake hydraulic drive unit?

18. Give the advantages and disadvantages of pneumatic brakes.
moprivoda.