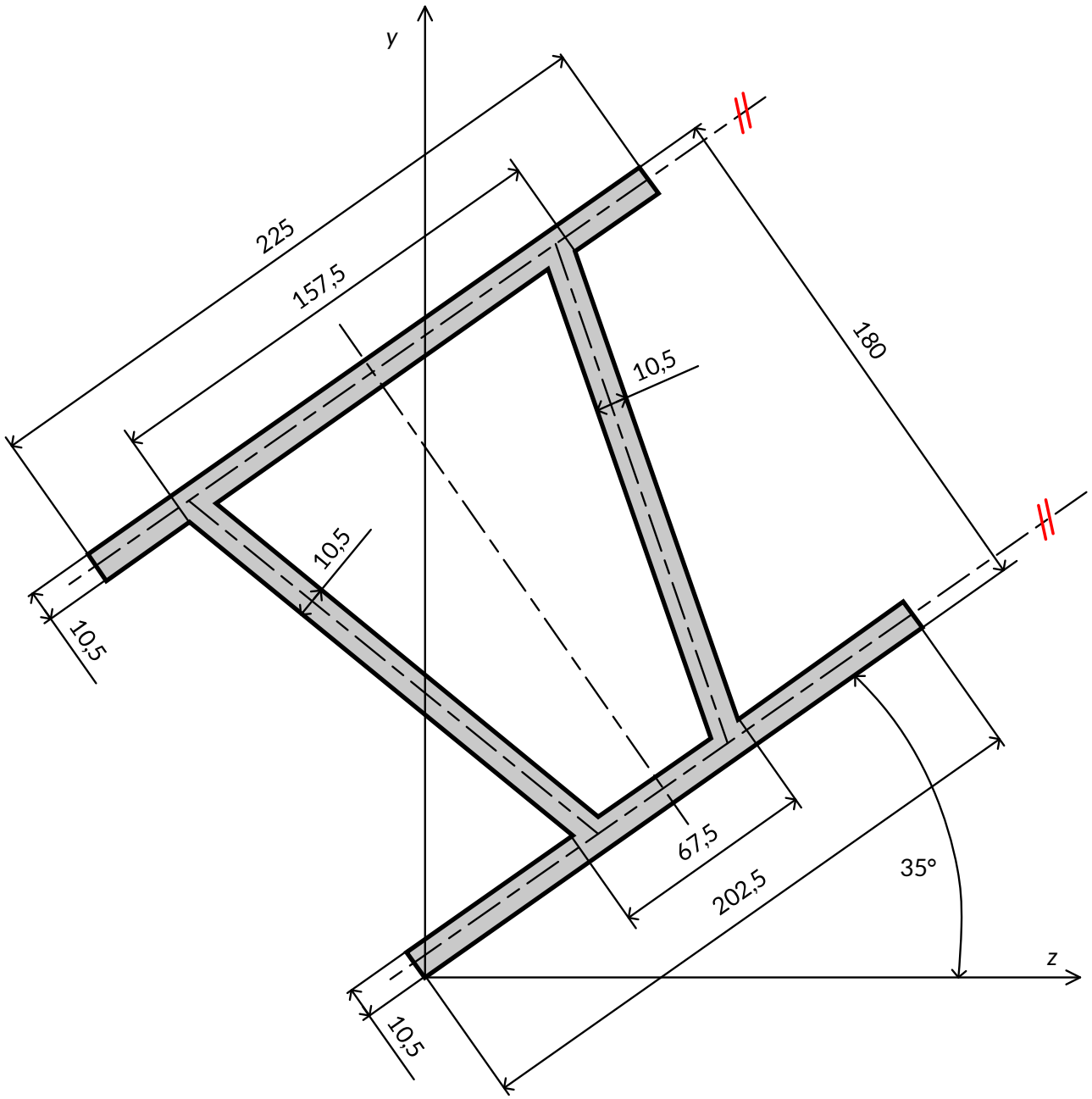
FSAA & FSP
2026 REGISTRATION QUIZ SOLUTIONS

Question 1
(3 points)

For the gray cross-section and its coordinate system given in the figure below, it is necessary to calculate:

- Center of gravity in mm (z_T, y_T) (0,5 points)
- Moment of inertia I_z in millions of mm^4 (0,5 points)
- Moment of inertia I_y in millions of mm^4 (0,5 points)
- Moment of inertia I_{zy} in millions of mm^4 (0,5 points)
- Radius of Gyration r_z in mm (0,5 points)
- Radius of Gyration r_y in mm (0,5 points)



Notes: Round the centers of gravity in mm to two decimal places. Round the moments of inertia in millions of mm^4 to three decimal places. Round the radii of Gyration in mm to two decimal places. Write with commas instead of dots, without the units of measurement.

SOLUTIONS:

- Center of gravity: z_T = 29,87 mm, y_T = 133,86 mm (0,5 points)
- Moment of inertia I_z = 35,352 (x 10^6 mm^4) (0,5 points)
- Moment of inertia I_y = 30,996 (x 10^6 mm^4) (0,5 points)
- Moment of inertia I_{zy} = -5,984 (x 10^6 mm^4) (0,5 points)
- Radius of Gyration r_z =66,65 mm (0,5 points)
- Radius of Gyration r_y =62,41 mm (0,5 points)

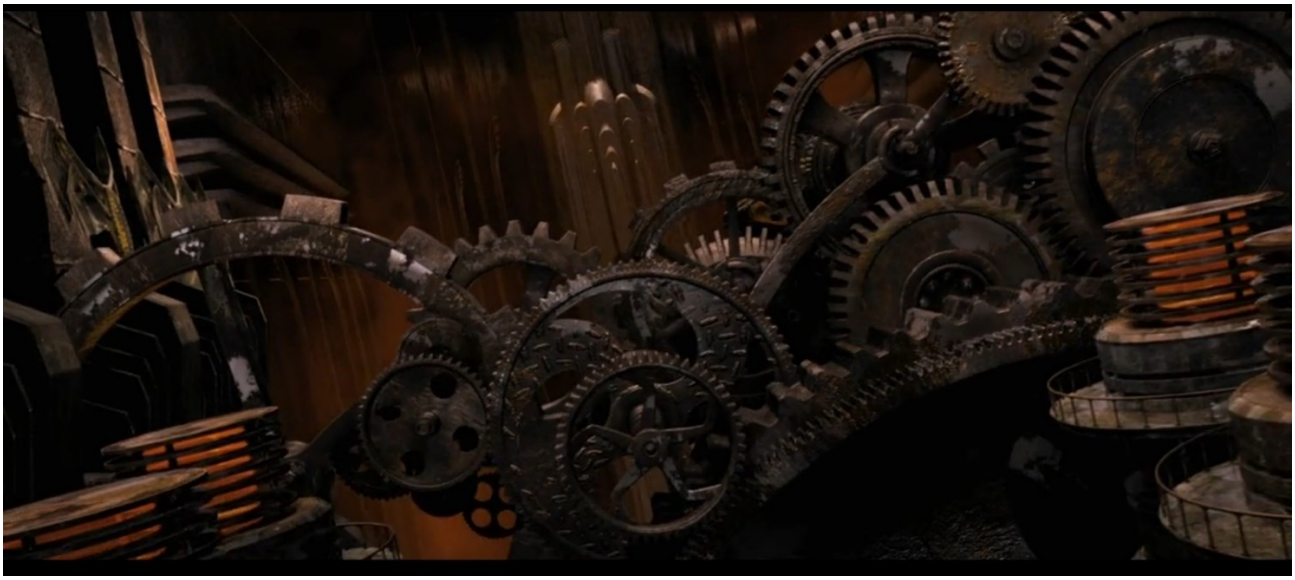
Question 2

(3 points)

Gears seem to be very popular in the film industry, either as a detail or as an important part of the content. Based on the figures shown below, name the film that the clip is associated with.

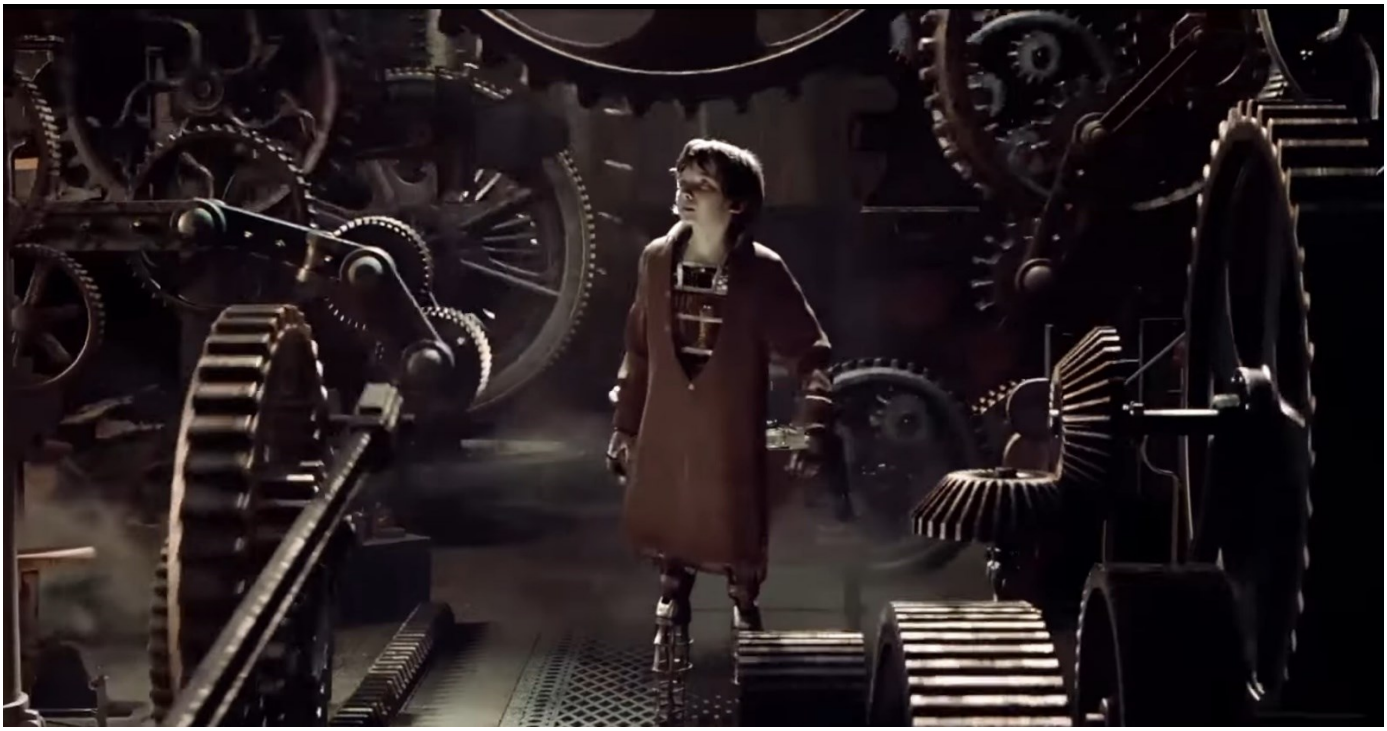
A – Modern times (0,5 point)

B – LIONSGATE opening credits (0,5 point)



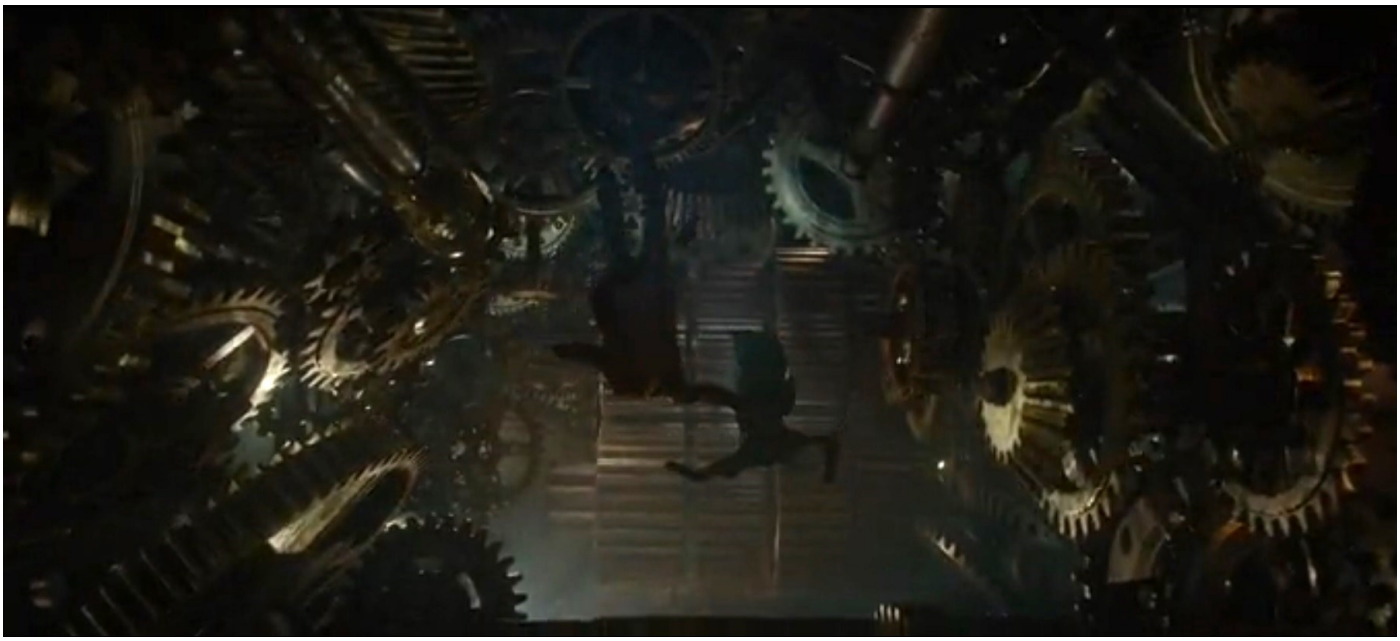
C – Golden Army (0,5 point)

D – Hugo (0,5 point)



E – The Amazing Spider-Man 2 (0,5 point)

F – The House with a Clock in Its Walls (0,5 point)

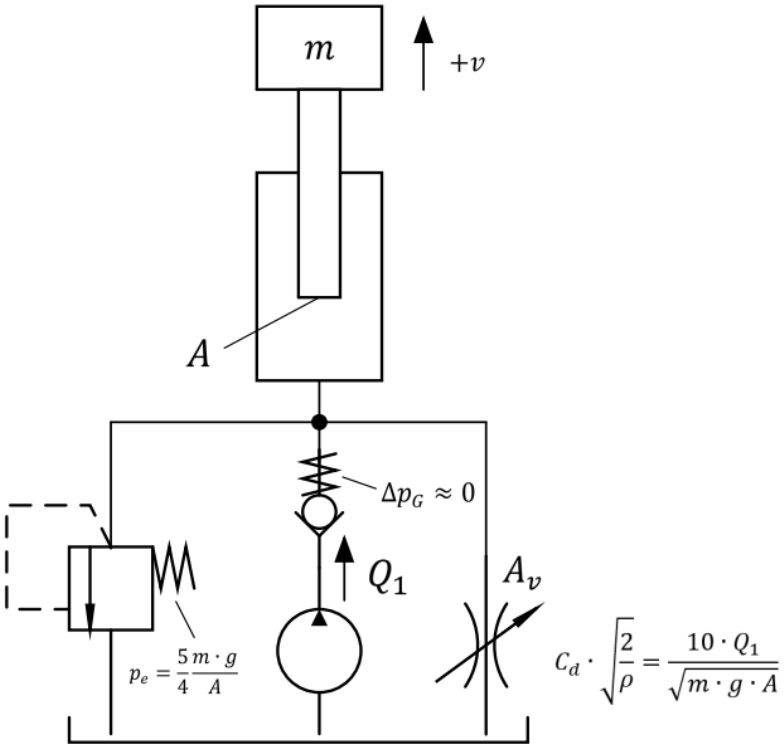


Question 3

(3 points)

The figure below shows a simplified hydraulic system consisting of a pump, a pressure relief valve, a check valve, an adjustable flow control valve and a plunger cylinder.

Working principle: The pump delivers oil to the cylinder. A check valve ensures that the oil flows only toward the actuator. An adjustable flow control valve regulates the speed of the piston movement. If the system pressure exceeds the permissible limit, the pressure relief valve opens and diverts the excess oil back to the tank, protecting the components. The cylinder then carries out the desired work task. Losses are not considered!



Given parameters: m, a, Q_1.

Calculate the flow area A_v of the adjustable flow control valve as a function of the given parameters, so that the following is obtained:

a) $v_1 = 0$

b) $v_2 = \frac{7}{10} \cdot \frac{Q_1}{A}$

c) $v_3 = -\frac{7}{10} \cdot \frac{Q_1}{A}$

Note: Write all the answers as the following combination (without the parentheses): [number] x [parameter]. The numbers should be written with two decimal places.

SOLUTIONS:

a) [0,10] x [A] or 0,10 x A

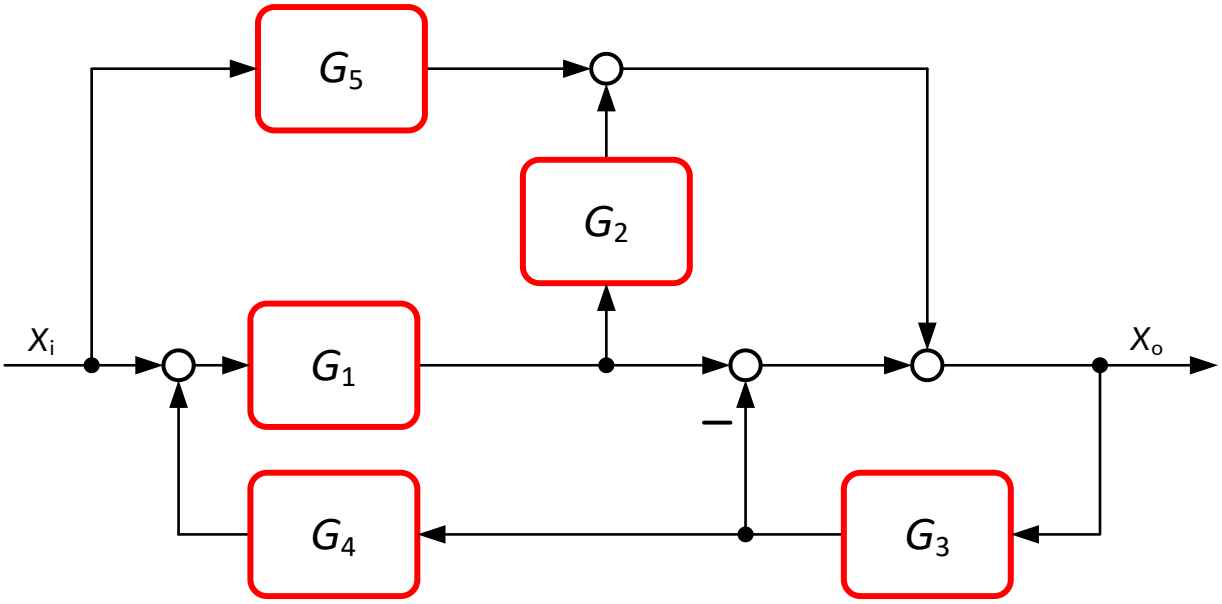
b) [0,03] x [A] or 0,03 x A

c) [0,17] x [A] or 0,17 x A

Question 4

(2 points)

Using block algebra from single-variable linear time-invariant continuous systems, determine the transfer function G (s) of system shown in block diagram in figure below.



SOLUTION:

$$G(s) = \frac{G_1 + G_5 + G_1 G_2}{1 + G_3 - G_1 G_3 G_4 - G_1 G_2 G_3 G_4}$$

Question 5
(3 points)

In an insulated cylinder there is water at an ambient temperature of 20 °C. Into the cylinder, 1 kg of ice at a temperature of −50 °C and 2 kg of ice at a temperature of −20 °C are added. Calculate:

5.1 What is the minimum number of kilograms of water that must be in the cylinder so that, at the moment equilibrium is reached, all of the ice melts? Write the answer with two decimal places.

5.2 How much ice would remain if there were half as much water in the cylinder as in **5.1**? Write the number in kilograms with two decimal places.

5.3 How much heat would need to be supplied to the contents of the cylinder, in the case from part (b), for the entire contents to turn into dry saturated steam? Write the number in kJ with two decimal places.

Notes: The specific heat capacities of water and ice may be considered constant and are 2 kJ/(kg·K) for ice and 4.187 kJ/(kg·K) for water. The melting temperature of ice is 0 °C, at which the latent heat of fusion of ice is 335 kJ/kg, and the boiling temperature of water is 100 °C, at which the latent heat of vaporization is 2200 kJ/kg.

SOLUTIONS:

5.1 14,15

5.2 1,77

5.3 26977,14

Question 6
(1 point)

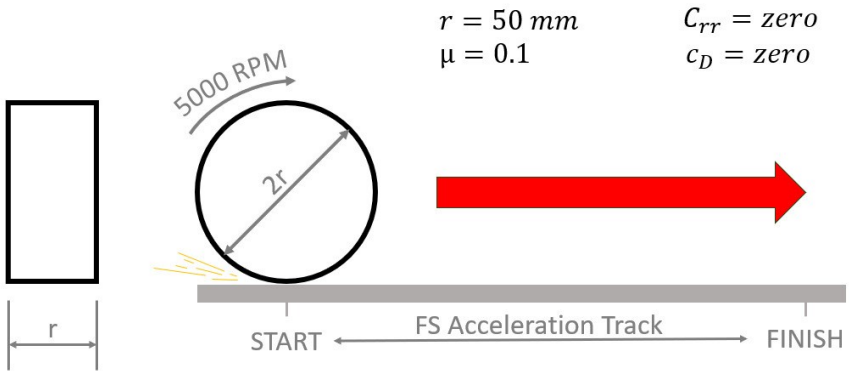
During pre-competition testing, your Formula Student team discovers the rear wing is killing your top speed on the straights. You need to redesign it (calculate the new drag coefficient) to keep the same downforce level but slash the rear wing drag, since it makes up half of your car's total drag coefficient C_D = 1,45.

Note: Round the answer to 4 decimal places.

SOLUTION: 0,4539

Question 7
(1 point)

A cylinder (mass of the cylinder is unknown, 100 mm diameter) is spun to 5000 RPM and put on a surface. The friction coefficient between the disk and the surface is 0,1. When the disk is released, it starts accelerating forward. In what time will the disk travel 75 meters?



Note: Write the number in seconds and round the answer to two decimal places.

SOLUTION: 13,04

Question 8
(1 point)

A Formula Student race car weighs 250 kg with the driver. Weight distribution is 45/55 front/rear and 50/50 left/right. The wheelbase is 1550 mm, the front track width is 1200 mm, and the rear track width is 1180 mm. Center of Gravity is 280 mm (assume longitudinal CoG is centered laterally). Assume all of the mass is unsprung. Determine the vertical load (in Newtons) on the front-left tire in a constant radius right-hand turn at a lateral load of 1,8 G. Assume g = 9,81 m/s^2, and that the car is traveling at a constant rate of speed.

Note: Round the answer to the nearest integer.

SOLUTION: 1015 N

Question 9
(4 points)

You are presented with a small, rounded cube on this link. Your objective is to determine the following:

9.1 Moment of inertia for all three axes (x, y, z) in grams * square millimeters rounded to two decimal places. The coordinate system is in the center of the cube.

9.2 Maximum von Mises stress in MPa rounded to two decimal places.

You are also given these inputs:

- The material of the cube is **Titanium Ti-5Al-2.5Sn** with these properties:
  - Elastic modulus: 110300 N/mm^2
  - Poisson's Ratio: 0.31
  - Shear Modulus: 48000 N/mm^2
  - Mass Density: 4480 kg/m^3
  - Tensile Strength: 861 N/mm^2
  - Compressive Strength: 830 N/mm^2
  - Yield Strength: 827 N/mm^2

- To determine the Maximum von Mises stress, use these input data:

Material model

- Linear elastic, homogeneous, isotropic
- Elastic modulus: 110300 N/mm^2
- Poisson's ratio: 0.31

Analysis type

- Static structural analysis
- Small-strain formulation
- Geometric nonlinearity disabled

Boundary conditions

- One flat face of the cube (excluding fillet surfaces) fully fixed in all translational and rotational degrees of freedom

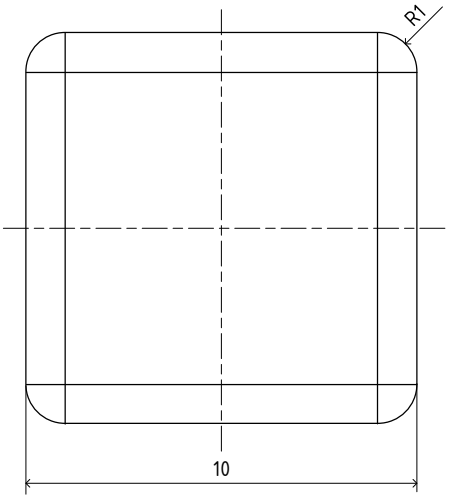
Load

- Uniform compressive surface traction applied to the opposite flat face (excluding fillets) from the one defined with boundary conditions
- Total resultant force: 100 N, acting normal to the surface

Meshing

- 3D quadratic tetrahedral solid elements (10-node or equivalent: for Abaqus C3D10, for Ansys: SOLID187, etc.)
- Average element edge length: 2,5 mm ± 10%
- Total element count: approximately 600–750 elements

Note: If you are having trouble with the cube on the link, here is a technical drawing so you can design it yourself:



SOLUTIONS:

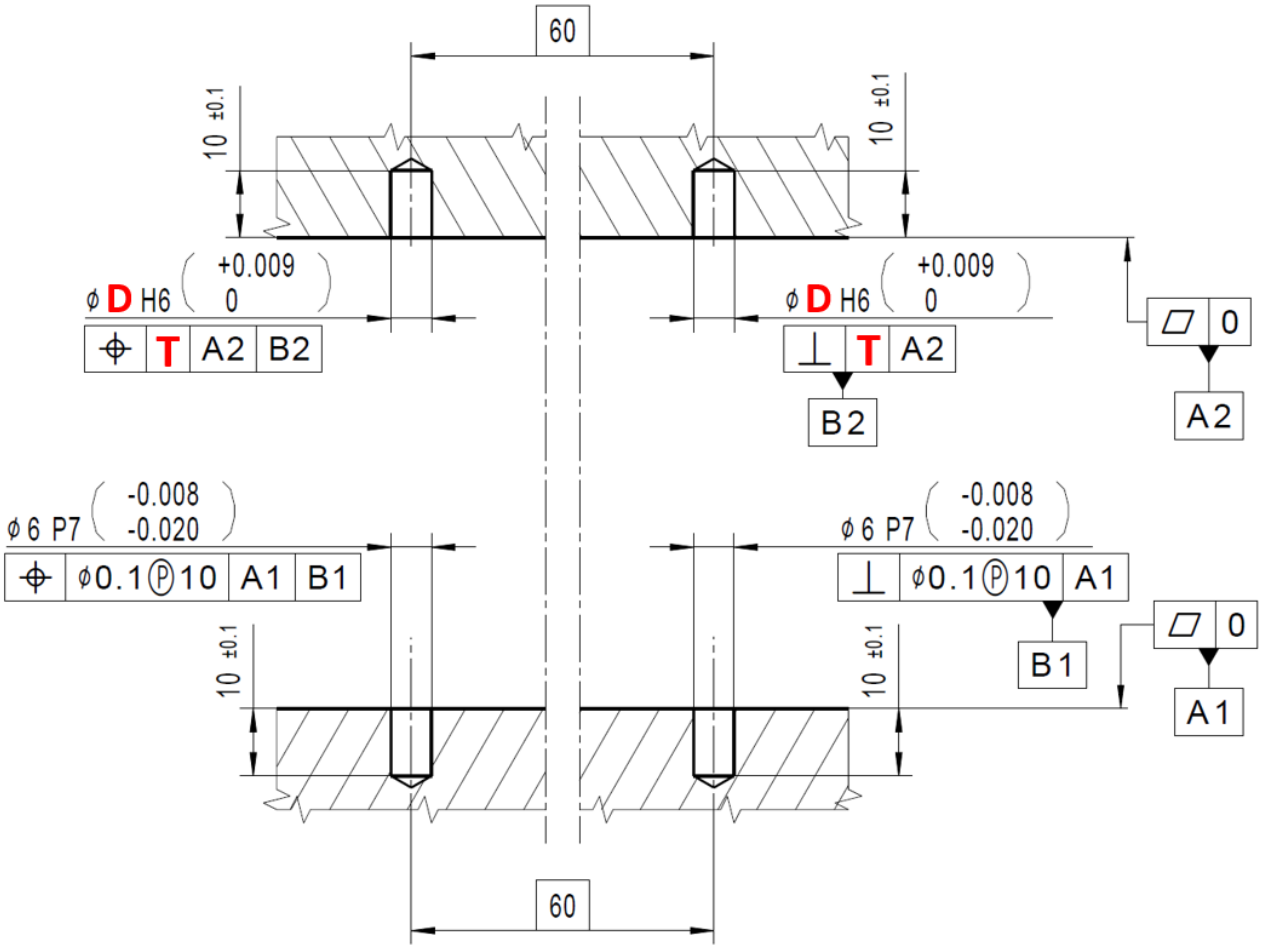
9.1 70,79 (we accept everything between 70,00 and 71,00)

9.2 4,52 (we accept everything between 4,00 and 5,00)

Question 10
(2 points)

10.1 For which can assembly of the two parts shown (using dowel pins) be guaranteed if produced according to specifications:

a) D = 6 T = ⌀0Ⓜ
b) D = 6,1 T= ⌀0,1Ⓜ
c) D = 6,1 T = ⌀0Ⓜ
d) D = 6 T = ⌀0,1



10.2 For correct answer, what is the worst-case linear misalignment in datum A plane (largest movement) which can happen between mating parts, considering all parts are within specifications?

Notes:

- Dowel pins used for assembly are DIN 7979 shape
- 2x ⌀6h6x20
- General product Specifications: ISO 8015
- Linear size ISO 14405 Ⓔ
- General tolerances: ISO 22081
- Edge finish: ISO 13715
- Surface Texture: ISO 21920-1

SOLUTIONS: 10.1 c; 10.2 0,117 mm or ±0,0585

Question 11
(2 points)

Your team has 3D printed a 15 % scale model of your FS vehicle. It seems that you're in luck – the university offers you to perform a test in a water tunnel instead of a wind tunnel. Your objective is to calculate (with a precision of 0.01 m/s) the speed at which water must flow through the tunnel to accurately represent the airflow around a full-scale vehicle, driven at 20 m/s. Consider that the desired dry air temperature is 30 °C, and the supplied water will be at 20 °C.

Determine if the pump supplied by the university can experiment with that calculated speed, knowing that:

- The water pump has a capacity of 95000 l/min,
- Tunnel cross-section is 0,2 m^2,
- Tunnel length is 3,1 m,
- Vehicle model occupies 10% of the tunnel cross-section area and 0,5 % of the tunnel volume,
- Disregard any possible effect from moving the ground.

Note: Write your answer in m/s in the following format (without the parentheses) with two decimal numbers: [x,xx] x [Yes/No].

Additional information:

Dry Air							
Tempera-ture	Density	Specific heat	Thermal conductivity	Thermal diffusivity	Viscosity	Dynamic viscosity	Prandtl number
t	ρ	Cp	λ	a	μ	ν	Pr
[°C]	[kg/m³]	[kJ/(kg·K)]	[W/(m·K) · 10²]	[m²/s · 10⁻⁵]	[N·s/m² · 10⁻⁶]	[m²/s · 10⁻⁶]	[-]
-50	1,584	1,013	2,04	12,7	14,6	9,23	0,728
-40	1,515	1,013	2,12	13,8	15,2	10,04	0,728
-30	1,453	1,013	2,2	14,9	15,7	10,8	0,723
-20	1,395	1,009	2,28	16,2	16,2	11,63	0,716
-10	1,342	1,009	2,36	17,4	16,7	12,43	0,712
0	1,293	1,005	2,44	18,8	17,2	13,28	0,707
10	1,247	1,005	2,51	20	17,6	14,16	0,705
20	1,205	1,005	2,59	21,4	18,1	15,06	0,703
30	1,165	1,005	2,67	22,9	18,6	16	0,701
40	1,128	1,005	2,76	24,3	19,1	16,96	0,699
50	1,093	1,005	2,83	25,7	19,6	17,95	0,698
100	0,946	1,009	3,21	33,6	21,9	23,13	0,688

Water							
Tempera-ture	Density	Specific heat	Thermal conductivity	Thermal diffusivity	Viscosity	Dynamic viscosity	Prandtl number
t	ρ	Cp	λ	a	μ	ν	Pr
[°C]	[kg/m³]	[kJ/(kg·K)]	[W/(m·K) · 10²]	[m²/s · 10⁻⁵]	[N·s/m² · 10⁻⁶]	[m²/s · 10⁻⁶]	[-]
0,01	999,9	4,212	55,1	13,1	1788	1,789	13,67
10	999,7	4,191	57,4	13,7	1306	1,306	9,52
20	998,2	4,183	59,9	14,3	1004	1,006	7,02
30	995,7	4,174	61,8	14,9	801,5	0,805	5,42
40	992,2	4,174	63,5	15,3	653,3	0,659	4,31
50	988,1	4,174	64,8	15,7	549,4	0,556	3,54
60	983,2	4,179	65,9	16	469,9	0,478	2,98
70	977,8	4,187	66,8	16,3	406,1	0,415	2,55
80	971,8	4,195	67,4	16,6	355,1	0,365	2,21
90	965,3	4,208	68	16,8	314,9	0,326	1,95
100	958,4	4,22	68,3	16,9	282,5	0,295	1,75
110	951	4,233	68,5	17	259	0,272	1,6

SOLUTIONS: 8,40; No

Question 12
(1 point)

Your team embarks on the important mission of figuring out whether the TS accumulator main fuse is correctly sized and not just pretending to be. Along the way, you discover that various industry standards all have their own opinions on what a proper short-circuit test for a tractive battery pack should look like. To keep things practical (and slightly dramatic), you decide to evaluate the fuse under the most likely real-life scenario you can imagine. This involves a short circuit at the charger output connector, occurring while the battery is partially discharged and has been thoroughly warmed up by high ambient temperatures.

Using the parameters and assumptions attached, please **calculate the maximum time it takes to open the circuit when short circuit condition is triggered (fuse maximum clearing time)**. Round the answer to the closest integer in ms.

Parameter	Value
Cell type	P50B
Battery pack temperature	45°C
Battery pack configuration	115S 3P
Battery pack SOC	60%
Total resistance of additional components in the power path (cell connectors, busbars, AIRs, pack connector)	7 mOhm
Ambient temperature	20°C
Total length of the charger output wire (short circuit loop)	8,8m
Cross-sectional area of charger wire	6 mm2
Material of the wire	Copper
Copper resistivity at 20°C	1,72 x 10-8 Ω·m
Used fuse type	Eaton/Bussman XEV20-150-SP

Table 1. Cell, Pack and wire parameters

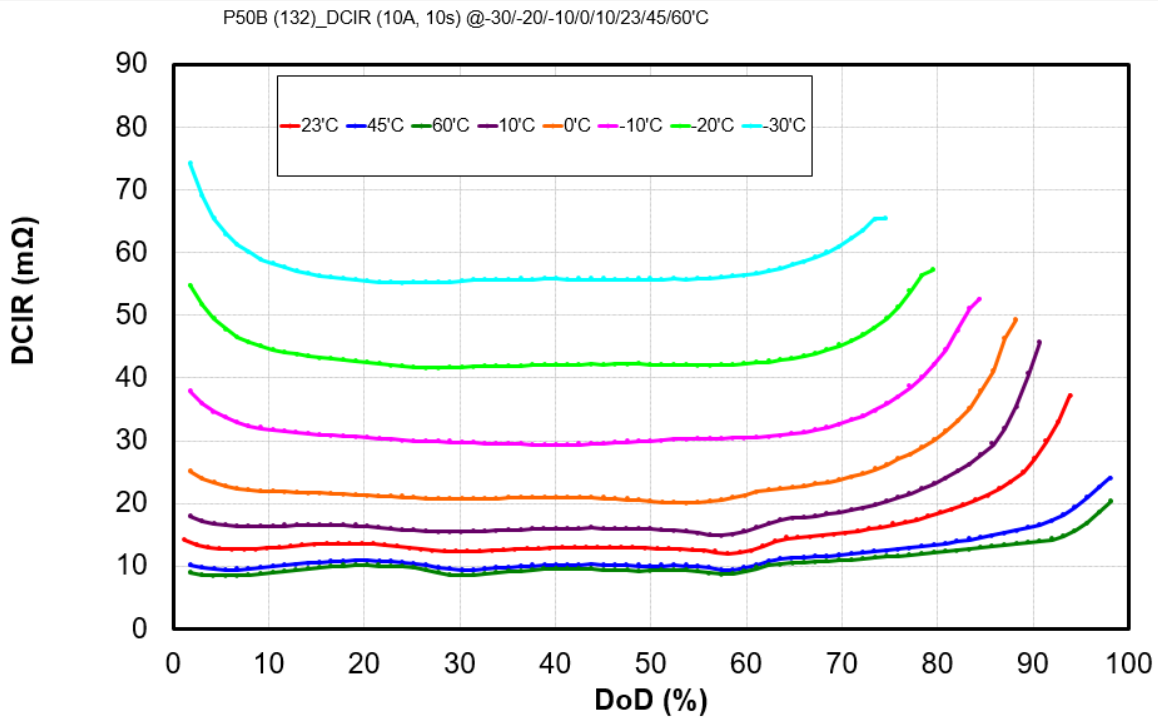


Figure 1. DCIR graph for different cell temperatures – P50B

P50B		OCV (V)			
SoC (%)		**45°C**	10°C	0°C	-10°C
Charge	100	4.167	4.161	4.160	4.158
Discharge	95	4.099	4.094	4.093	4.092
	90	4.078	4.074	4.073	4.072
	85	4.049	4.046	4.045	4.045
	80	3.997	3.994	3.993	3.992
	75	3.942	3.938	3.937	3.937
	70	3.878	3.870	3.868	3.867
	65	3.838	3.831	3.829	3.828
	60	3.798	3.792	3.790	3.789
	55	3.746	3.745	3.744	3.744
	50	3.678	3.678	3.678	3.678
	45	3.610	3.611	3.611	3.612
	40	3.558	3.559	3.559	3.559
	35	3.508	3.516	3.518	3.519
	30	3.441	3.450	3.453	3.455
	25	3.360	3.369	3.372	3.373
	20	3.278	3.287	3.290	3.291
	15	3.186	3.197	3.200	3.202
	10	3.066	3.076	3.079	3.081
	5	2.943	2.950	2.952	2.954
	0	2.821	2.832	2.835	2.836

Figure 2. SOC (%) vs OCV (V) for different cell temperatures – P50B

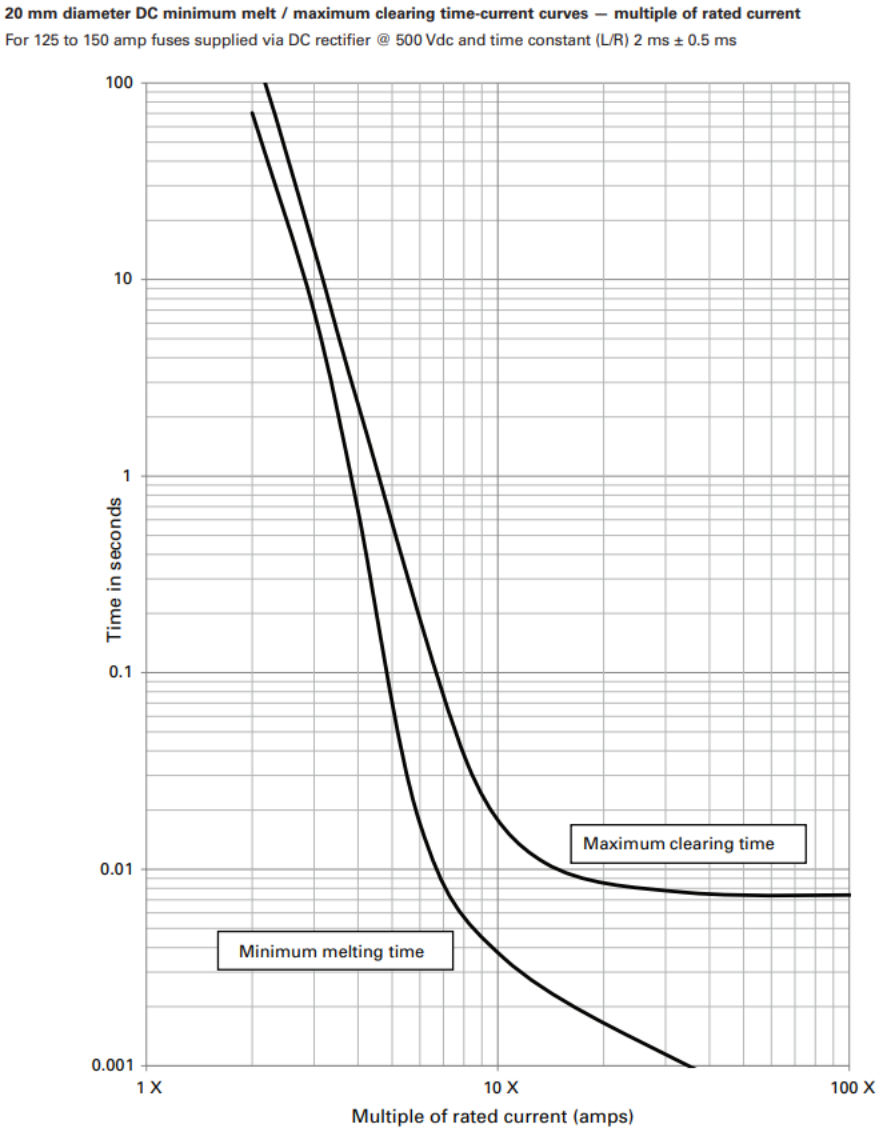


Figure 3. Max clearing time / current curve for Eaton XEV20-150-SP

Notes/assumptions:

- Temperature of the cells stays constant for the whole duration of the short circuit condition
- Temperature of the conductive elements in the high current path stays constant for the whole duration of the short circuit condition
- Assume that battery pack was not charged or discharged

Sources:

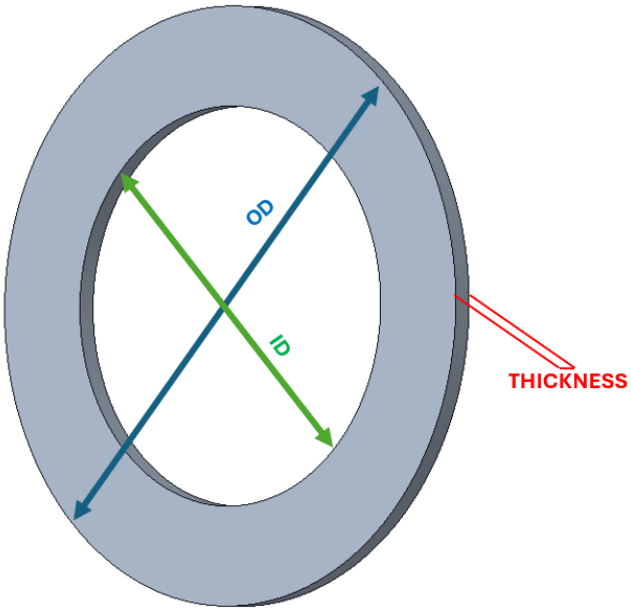
- Eaton XEV20-150-SP datasheet - https://www.eaton.com/content/dam/eaton/products/emobility/fuses-electric-vehicle/bus-ele-ds-10863-ev-pre-production-sample-power-fuses.pdf
- Molicel P50B technical information

SOLUTION: 70 ms – 80 ms, all the answers from this range will be accepted due to the accuracy of reading from the graphs.

Question 13
(3 points)

A race car is going on the long straight at 180 km/h. Unfortunately, the rear brakes don't work, so it can use only the front brakes to slow down. It is approaching a slow right corner, for which the entering speed must be no more than 90 km/h. While braking, the weight distribution is 60% front and 40% rear. Assume:

- No heat transfer from the brake discs to the wheel hub
- Braking force is constant
- Brake discs are "floating" type, solid (non-ventilated)
- Assume no aerodynamic forces are acting on the car (no "aero" braking)



Car info:

- Mass = 1200 kg
- Effective diameter of the front brake discs = 350 mm
- Average friction coefficient for the front brake pads/discs μ = 0,38
- Average braking force (per 1 calliper) = 55 kN

Your job is to calculate:

13.1 Total energy to be dissipated to slow down the car to 90 km/h, give the result in J, rounded to the closest integer.

13.2 Braking torque per 1 disc, give the result in Nm, round the results to 1 decimal place.

13.3 Temperature increase of 1 brake disc if the weight of a brake disc is 7,2 kg, specific heat c = 460 J/(kg*K), and 70% of energy is transferred to the brake disc. Give the result in °C, round to the nearest integer.

SOLUTIONS:

13.1 1125000

13.2 3657,5

13.3 119