FSCH Registration Quiz 2023 V2.0

Q1

You want to drive with your FS Car after the competition to Zermatt to visit the famous Matterhorn. The first 70% of the distance, you can drive with a constant speed of 80 km/h. Due to traffic jams, you have to drive 30 km/h for the remaining distance. The distance from the competition to Täsch is 74 km. How much energy is needed if your average consumption is 10 kJ/s.

Answer in kWh.

Use the following format: 12.3

Answer: 13.9

$$d_1 = 70\% * 74\ km = 51.8\ km$$

$$d_2 = 30\% * 74\ km = 22.2\ km$$

$$t_1 = \frac{d_1}{v_1} = \frac{51.8\ km}{80\ km/h} = 0.6475\ h = 2331\ s$$

$$t_2 = \frac{d_2}{v_2} = \frac{22.2\ km}{30\ km/h} = 0.74\ h\ = 2664\ s$$

$$t = t_1 + t_2 = 4995\ s$$

$W = P * t = 10\ kJ/s * 4995\ s = 49950\ kWs = 13.875\ kWh$ (Note: 1 kJ = 1kWs)

Additional note for those actually interested in visiting Matterhorn: From Täsch, there is a train going to Zermatt, where it is visible to see the mountain.

Q2

What is the minimal flexural stiffness required for Front Hoop Bracing Structure on your complete Formula Student racecar?

Answer in Nm^2.

Use the following format: 12

Answer: 3404

T 3.11.1: FS cars need a minimum of 2 tubes (1 tube on either side) & T 3.2: 1 tube requires an EI of at least 1702 Nm^2.

Q3

Which proposal is not a mesh refinement technique?

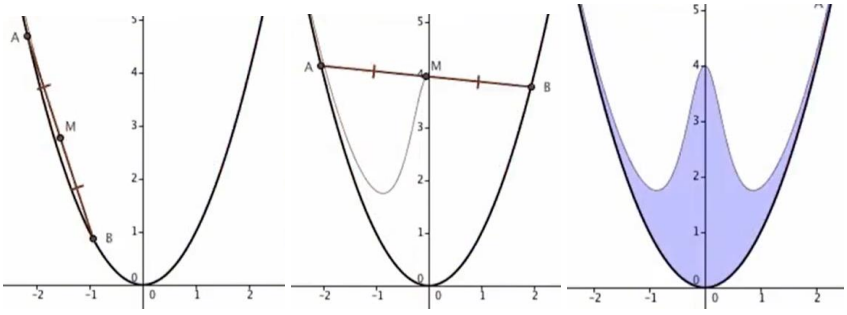
a) Global element size reduction
b) Local element size reduction
c) Guyan reduction
d) Increasing the order of the elements

Answer: c)

Q4

A curve is given as $f_1(x) = x^2$. Two points, connected as a line with a constant distance of exactly 4, are travelling on this curve. Its midpoint is generating a new curve. Calculate the area between both curves.

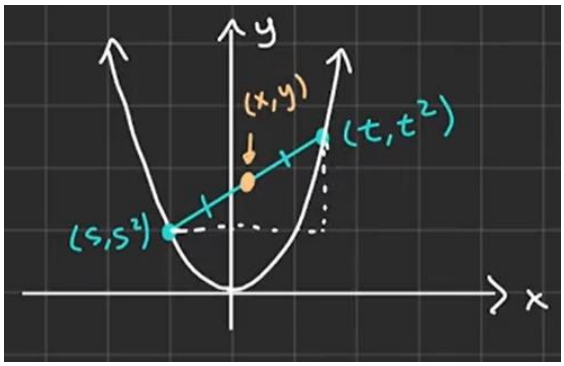
Hint: See the graph below given for random timestamps:



Answer has no units.

Use the following format: 12.34

Answer: 6.28



$x = \frac{s+t}{2}\ y = \frac{s^2+t^2}{2}$ $\quad (t-s)^2 + (t^2-s^2)^2 = 16 \quad y = x^2$

$$(t-s)^2 + (t^2-s^2)^2 = 16$$

$$\Rightarrow (t-s)^2 + ((t-s)(t+s))^2 = 16$$

$$\Rightarrow (t-s)^2 + (t-s)^2(t+s)^2 = 16$$

$$\Rightarrow (t-s)^2(1 + (t+s)^2) = 16 \quad | \ x = \frac{s+t}{2} \Rightarrow s+t = 2x$$

$$\Rightarrow (t-s)^2(1 + (2x)^2) = 16$$

$$\Rightarrow (t-s)^2(1 + 4x^2) = 16$$

$$\Rightarrow (t-s)^2 = \frac{16}{1+4x^2}$$

$$\Rightarrow t^2 - 2ts + s^2 = \frac{16}{1+4x^2} \quad | \quad y = \frac{s^2+t^2}{2} \Rightarrow t^2 + s^2 = 2y$$

$$\Rightarrow 2y - 2ts = \frac{16}{1+4x^2} \quad | \quad 2y = t^2 + s^2$$

$$| \Rightarrow \quad 2y = t^2 + 2ts + s^2 - 2ts$$

$$| \Rightarrow \quad 2y = (t+s)^2 - 2ts$$

$$| \Rightarrow \quad 2y = (2x)^2 - 2ts$$

$$| \Rightarrow \quad -2ts = 2y - 4x^2$$

$$\Rightarrow 2y + 2y - 4x^2 = \frac{16}{1+4x^2}$$

$$\Rightarrow 4y - 4x^2 = \frac{16}{1+4x^2}$$

$$\Rightarrow y - x^2 = \frac{4}{1+4x^2}$$

$$\Rightarrow f_2(x) = y = x^2 + \frac{4}{1+4x^2}$$

Area: $A = \int_{-\infty}^{+\infty} f_2(x) - f_1(x)dx$

$$= \int_{-\infty}^{+\infty} x^2 + \frac{4}{1+4x^2} - x^2 dx$$

$$= \int_{-\infty}^{+\infty} \frac{4}{1+4x^2} dx$$

$$= [2 * arctan(2x)]_{-\infty}^{+\infty}$$

$$= 2\pi = 2 * 3.1415\ldots = 6.283\ldots$$

Q5

What is not true about VSV?

a) The video has to be made in a described order.
b) Passenger cars are not allowed to drive in the background.
c) Will be reviewed in order of submission.
d) The maximum length of the video is limited.

Answer b) - Passenger cars can be driven in the background if the area/premise is clearly separated (A 6.4.6)

Q6

Due to difficulties passing technical inspection, your team could only try 1 run for Autocross. Your driver achieved a time of 68.2s and was hitting 3 cones. Post-Scrutineering was passed without penalties. The overall best time was 62.5s without hitting any cones. What is your score?

Use the following format: 12.3

Answer: 24.7

D 6.3.1 → 4.5 points for the run

and

D 6.3.2 → $95.5 * \frac{\frac{1.25*62.5s}{68.2s+2s*3} - 1}{0.25} = 20.2$ points for the time

Q7

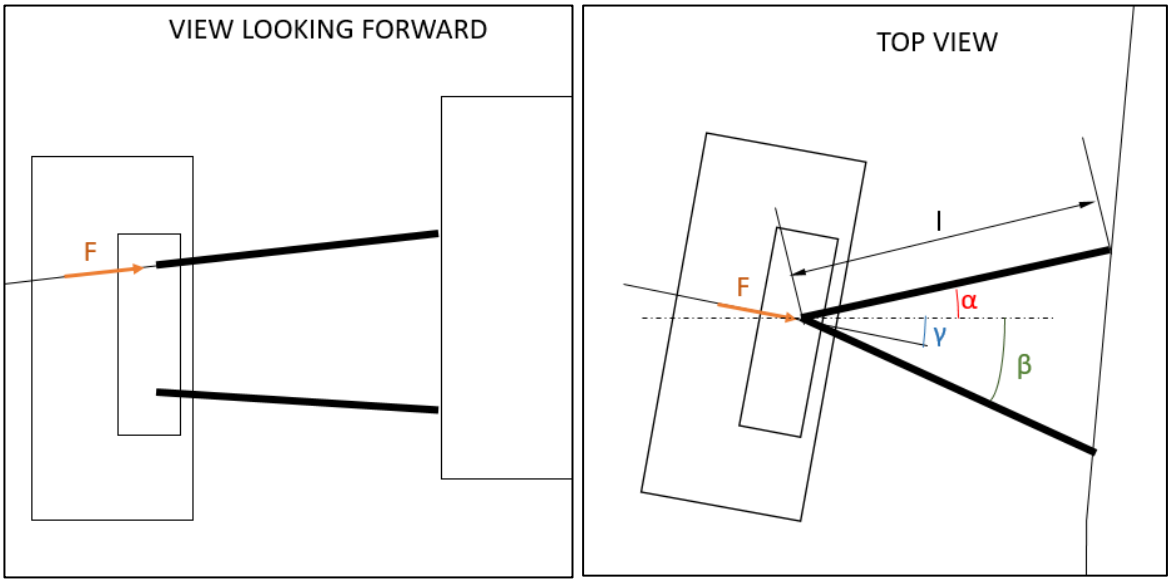
What is not true about the 95th percentile male (Percy)?

a) Percy cannot have his own seat.
b) Percy is only represented in 2D.
c) A Driver may be taller than Percy.
d) Percy wears a helmet.

Answer: a)

Q8

Due to many suspension problems the previous year, the A-Arms shall be redesigned. According to the following geometrical arrangement, what is the min. wall thickness of your rods considering only buckling case. Assume your A-Arms are made of round tubular steel, tubes have the same length and the transferred tyre load is acting in the same plan as the A-Arm.

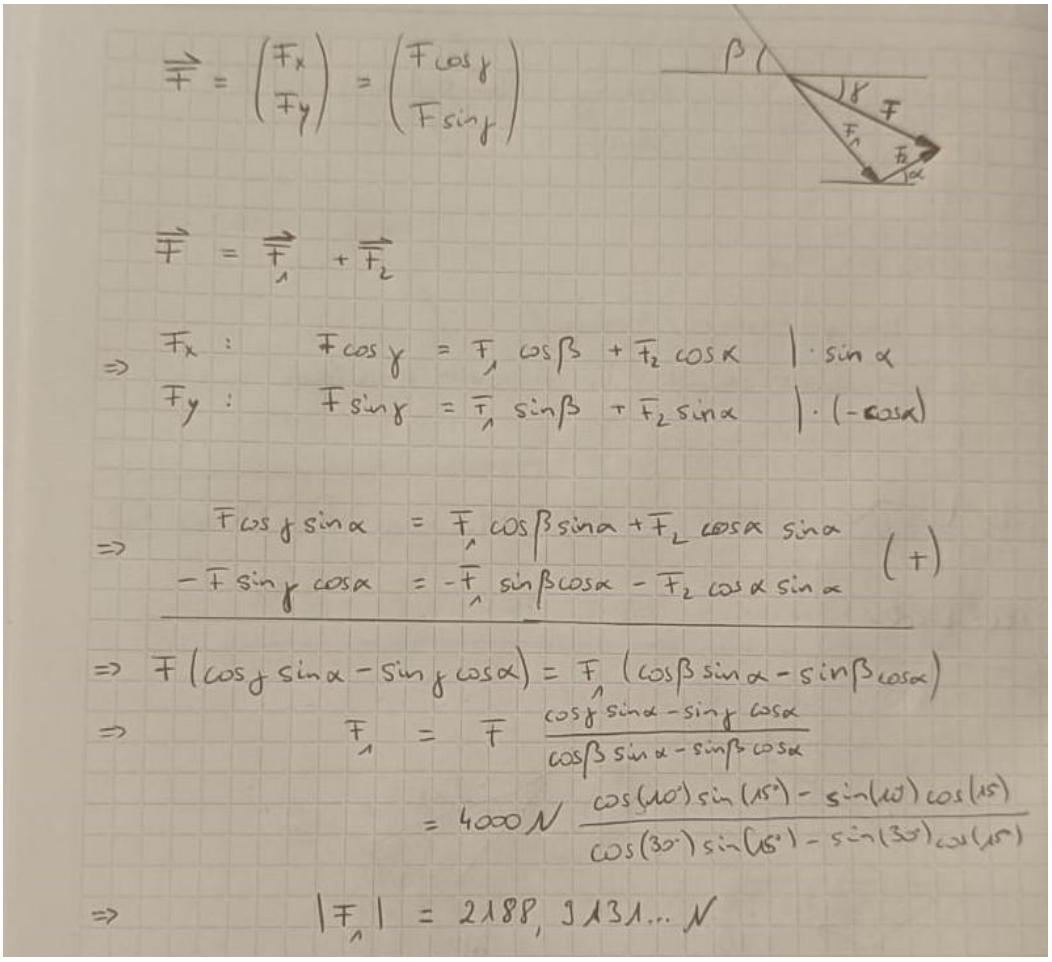


$E = 210\ GPa$ $D_{outer} = 15\ mm$ $F = 4000\ N$ $\alpha = 15°$ $\beta = 30°$ $\gamma = 10°$
$l = 350\ mm$ $K = 1$ (column effective length factor)

Answer in mm

Use the following format: 12.3

Answer: 0.1



$$\vec{F} = \begin{pmatrix} F_x \\ F_y \end{pmatrix} = \begin{pmatrix} F\cos\gamma \\ F\sin\gamma \end{pmatrix}$$

$$\vec{F} = \vec{F}_1 + \vec{F}_2$$

$$\Rightarrow \quad F_x: \quad F\cos\gamma = F_1\cos\beta + F_2\cos\alpha \quad | \cdot \sin\alpha$$
$$F_y: \quad F\sin\gamma = F_1\sin\beta + F_2\sin\alpha \quad | \cdot (-\cos\alpha)$$

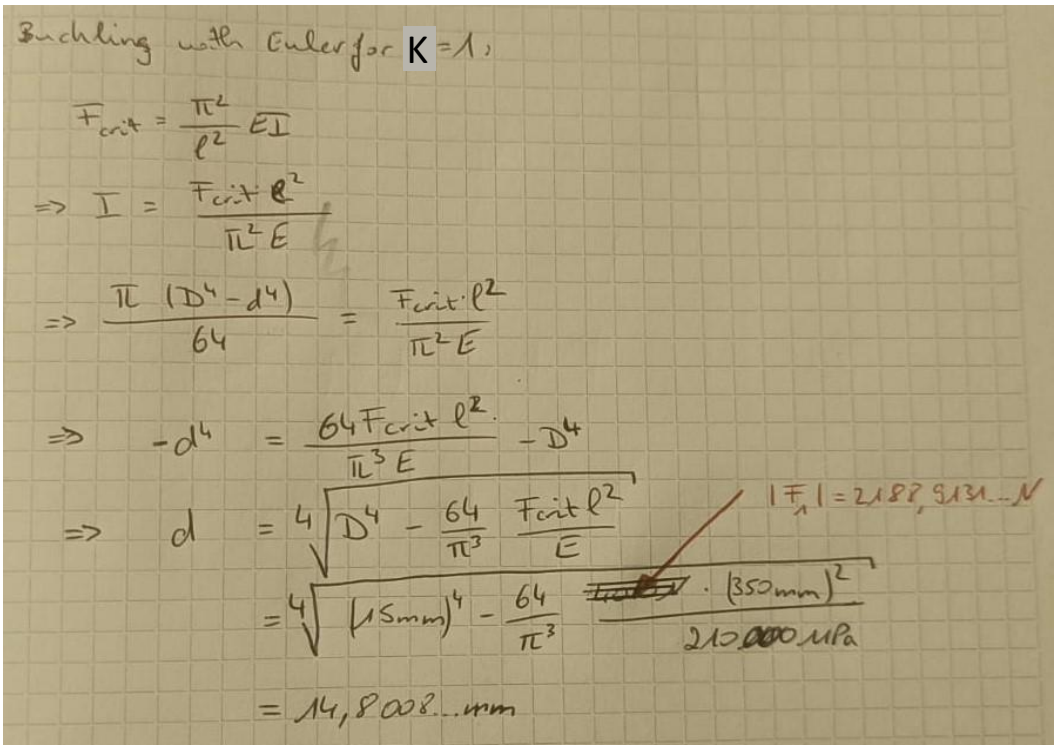
$$\Rightarrow \quad F\cos\gamma\sin\alpha = F_1\cos\beta\sin\alpha + F_2\cos\alpha\sin\alpha$$
$$-F\sin\gamma\cos\alpha = -F_1\sin\beta\cos\alpha - F_2\cos\alpha\sin\alpha \quad (+)$$

$$\Rightarrow F(\cos\gamma\sin\alpha - \sin\gamma\cos\alpha) = F_1(\cos\beta\sin\alpha - \sin\beta\cos\alpha)$$

$$\Rightarrow F_1 = F\,\frac{\cos\gamma\sin\alpha - \sin\gamma\cos\alpha}{\cos\beta\sin\alpha - \sin\beta\cos\alpha}$$

$$= 4000\,N\,\frac{\cos(10°)\sin(15°) - \sin(10°)\cos(15°)}{\cos(30°)\sin(15°) - \sin(30°)\cos(15°)}$$

$$\Rightarrow \quad |F_1| = 2188{,}9131\ldots\,N$$



Buckling with Euler for K = 1:

$$F_{crit} = \frac{\pi^2}{l^2} EI$$

$$\Rightarrow I = \frac{F_{crit}\,l^2}{\pi^2 E}$$

$$\Rightarrow \frac{\pi(D^4 - d^4)}{64} = \frac{F_{crit}\cdot l^2}{\pi^2 E}$$

$$\Rightarrow -d^4 = \frac{64 F_{crit}\,l^2}{\pi^3 E} - D^4$$

$$\Rightarrow d = \sqrt[4]{D^4 - \frac{64}{\pi^3}\frac{F_{crit}\,l^2}{E}}$$

$|F_1| = 2188{,}9131\ldots\,N$

$$= \sqrt[4]{(15mm)^4 - \frac{64}{\pi^3}\,\frac{\cdot\,(350mm)^2}{210000\,MPa}}$$

$$= 14{,}8008\ldots\,mm$$

WT = (D-d)/2 = 0.09.... mm

Q9

What could happen if your team misses the initial deadline by more than 3 days, for example the SES upload.

a) No actions applicable, as the correction request was on time.
b) If the corrected version of the document does not completely contain all requested corrections, the team will be de-registered from the competition.
c) A team may receive 20 penalty points.

Answer: c) - Late submissions more than 1 day for the initial deadline results in de-registration of the team (A 5.3.2). Teams may reapply and positively confirmed requests will result in 20 penalty points (A 5.5.3).

Q10

What kind of mesh density do you use in regions where you expect high gradients of strains or stresses?

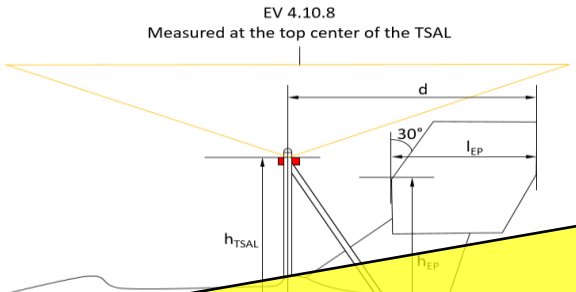
a) Low mesh density
b) High mesh density
c) Transition mesh

Answer: b)

Q11

Your aerodynamic team designed a new Rear Wing as shown below at the maximum allowed height. What is the minimum height of your TSAL (h_{TSAL}) considering it's mounted directly below the top of your Main Hoop? Assume, your car is 2D only.

$d = 800 \quad l_{EP} = 380\,mm \quad h_{EP} = 900mm$



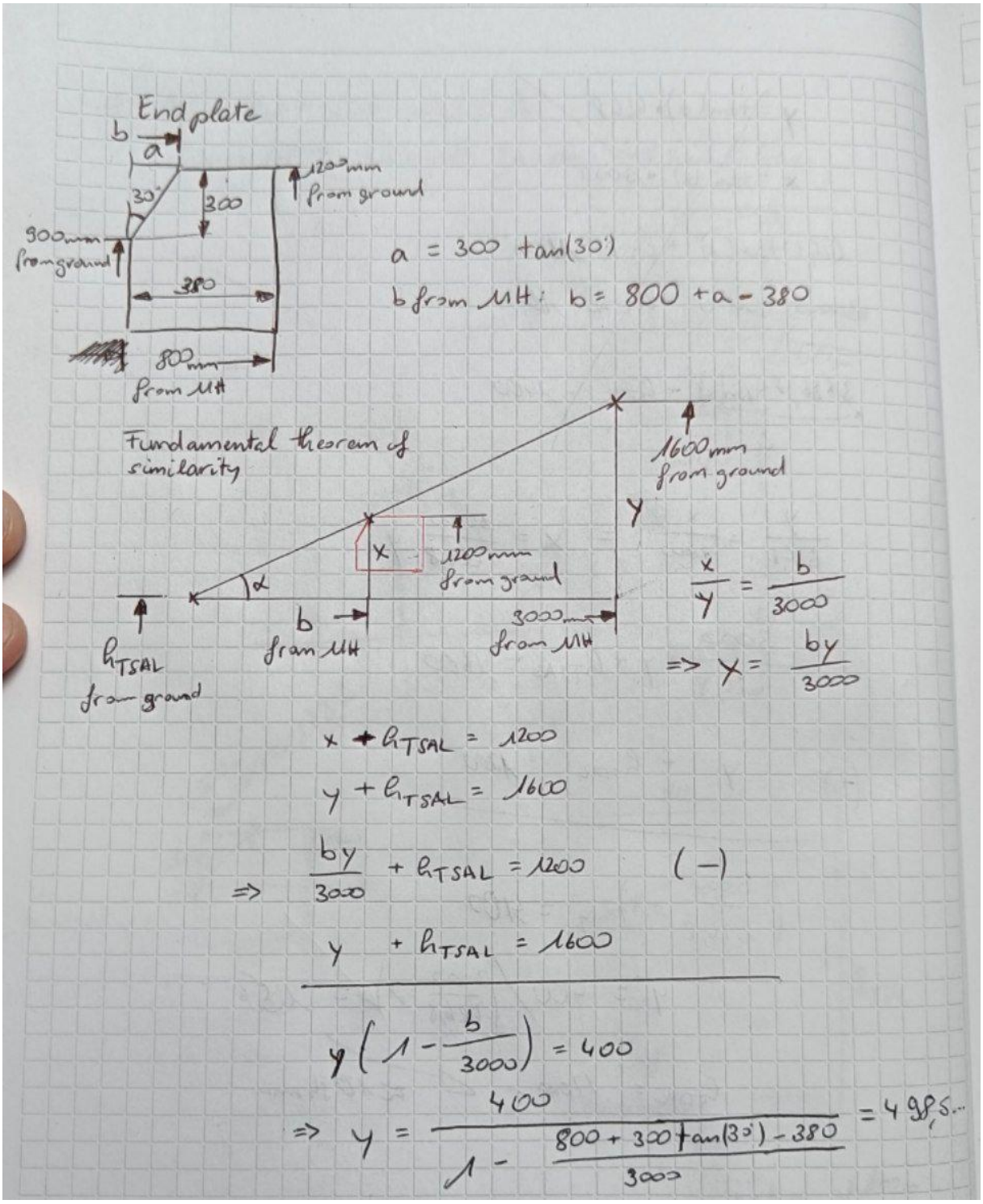
Protest granted, rounding to 1101 mm resulting in not seeing the TSAL & leading to a non-rules compliant vehicle

Accepted answer expended to 1101 and 1102

Answer in mm

Use the following format: 12

Answer: 1101



$h_{TSAL} = 1600\,mm - 498,5...\,mm = 1101,4...\,mm \Rightarrow \boxed{1101\,mm}$

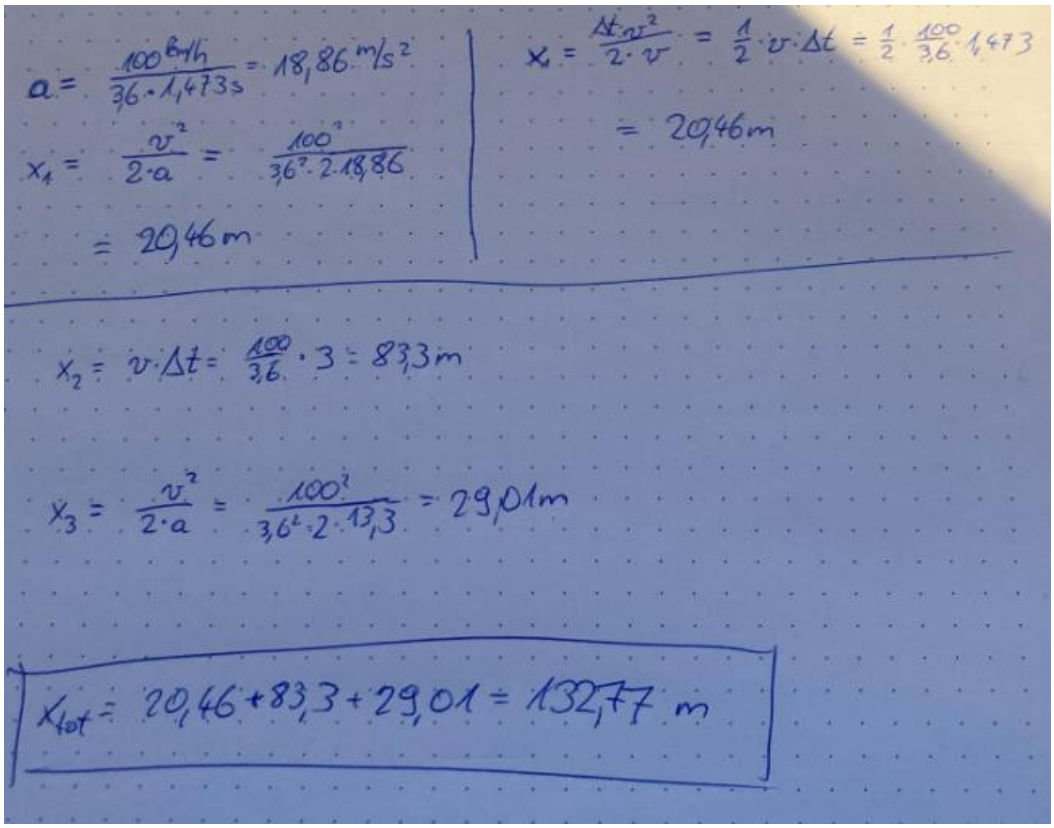
Q12

Your team decides to beat the newly acquired World Record from Greenteam. You didn't achieve to beat them, but set a respectable time of 1.473 s. Your driver continues to drive 100 km/h for another 3 s and then braking with 13.3 m/s^2. Assume that acceleration and deceleration are linear. What is the distance travelled by your car?

Answer in m.

Use the following format: 12.3

Answer: 132.8



Q13

What is the basic equation for electrical engineering:

a) U=R+I
b) R=U*I
c) I=U/R
d) U+I/R=0

Answer: c) U=R*I (Ohm's law)

Q14

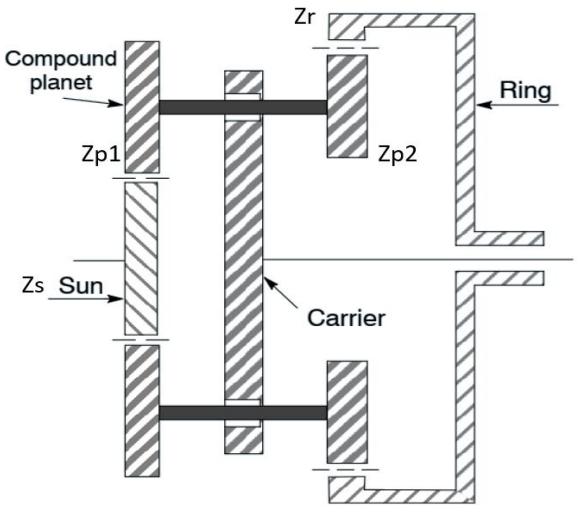
A compound planetary gearbox has the following parameters:

$Z_s = 25 \quad mod_1 = 2mm \quad mod_2 = 3.015mm \quad Z_{P1} = 76 \quad Z_r = 86$

mod_X means Module Xth stage

Z_{PX} means Planet Xth stage

Calculate the speed ratio defined as input/output speed. Assume sun gear is input, carrier is output, ring gear is fixed.



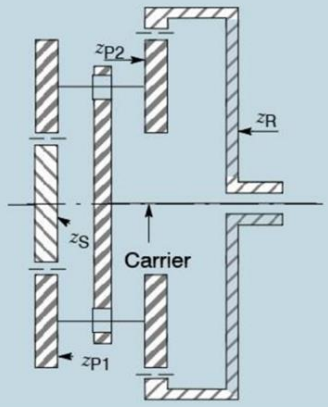
Answer in dimensionless units.

Use the following format: 12.34

Answer: 14.76

$$mod_1(Z_s + Z_{P1}) = mod_2(Z_r - Z_{P2})$$

Speed ratio:

Gear arrangement	Input	Fixed	Output	Direction of rotation	Speed ratio[1)]
B 	Sun	Ring	Carrier	Same	$\frac{(z_{P2} z_S + z_{P1} z_R)}{(z_{P2} z_S)}$
	Sun	Carrier	Ring	Opposite	$-\frac{(z_{P1} z_R)}{(z_{P2} z_S)}$
	Carrier	Ring	Sun	Same	$\frac{(z_{P2} z_S)}{(z_{P2} z_S + z_{P1} z_R)}$
	Carrier	Sun	Ring	Same	$\frac{(z_{P1} z_R)}{(z_{P2} z_S + z_{P1} z_R)}$
	Ring	Carrier	Sun	Opposite	$-\frac{(z_{P2} z_S)}{(z_{P1} z_R)}$
	Ring	Sun	Carrier	Same	$\frac{(z_{P2} z_S + z_{P1} z_R)}{(z_{P1} z_R)}$

Q15

You designed a new discharge circuit for your inverter. Your maximum DC Link Voltage is 500 V and you have a DC Link capacity of 400 uF. Your circuit discharges with a constant current of 50 mA and has a maximum operating Temperature of 125 °C. The used cooling plate has a Thermal capacity of 3 J/K and a thermal resistance to the surrounding air of 0.2 W/K. Other thermal influences can be regarded as ideal. Is your circuit rules compliant?

a) Yes
b) No

Protest granted, removed from ranking
Amb. Temp. missing in Question
Any time spent will be ignored on total time

Answer: b) No

Q = C*V = 200mC
I = Q/4s = 50mA
P_max = U*I = 25W
E = 1/2C*V^2 = 50 Joule
T_max = P_max/R_th(a) + T_amb = 25/0.2 + T_amb = 125°C + 25°C => way to hot.