Registration Quiz 2026 Solutions

Formula Student Portugal

Formula Student Switzerland

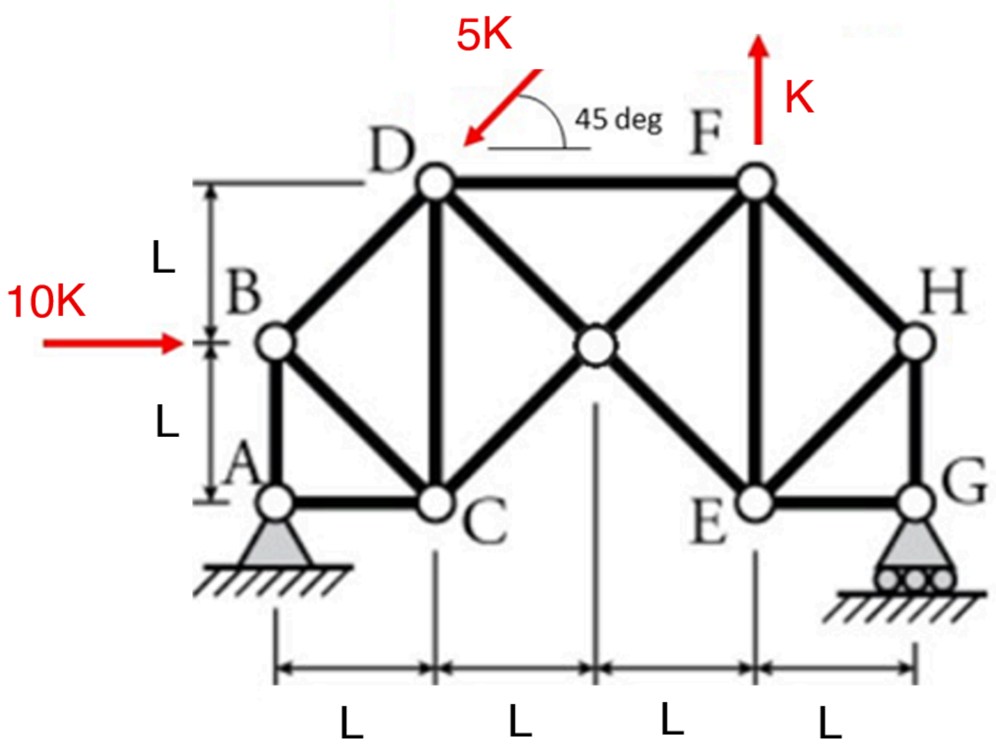
02/02/2026

Common Questions

#1 Structural analysis

Expected Time: 4 min

Question:
Considering the image below and the loads applied, what is the force in the element HG? Consider K=20N.



Answer format: Do not round any intermediate results. Provide your answer in N and follow the sign convention “-” for a compressive force and “+” for tensile. Use the following format: +12.345 or -1.234 (no ',' comma, no letters), round final result to 3 decimal places.

Answer: -17.322

Resolution:

Sum of moments around A:

$$f_{GH} * 4L = -10K * L - 5K * \sin(45°) * L + 5K * \cos(45°) * 2L + K * 3L$$

Divide by L:

$$4f_{GH} = -10K - 5K * \sin(45°) + 5K * \cos(45°) * 2 + 3K$$

$$\sin(45^{\circ}) = \cos\ (45^{\circ})$$

$$4f_{GH} = K(-10 + 5 * \cos(45^{\circ}) + 3)$$

$$4f_{GH} = 20(-7 + 5 * \cos(45^{\circ}))$$

Divide by 4: $4f_{GH} = K(-10 - 5 * \sin(45^{\circ}) + 10 * \cos(45^{\circ}) + 3)$

$$f_{GH} = 5(-7 * 5 * \cos(45^{\circ}))$$

$$f_{GH} = -17.322\ N$$

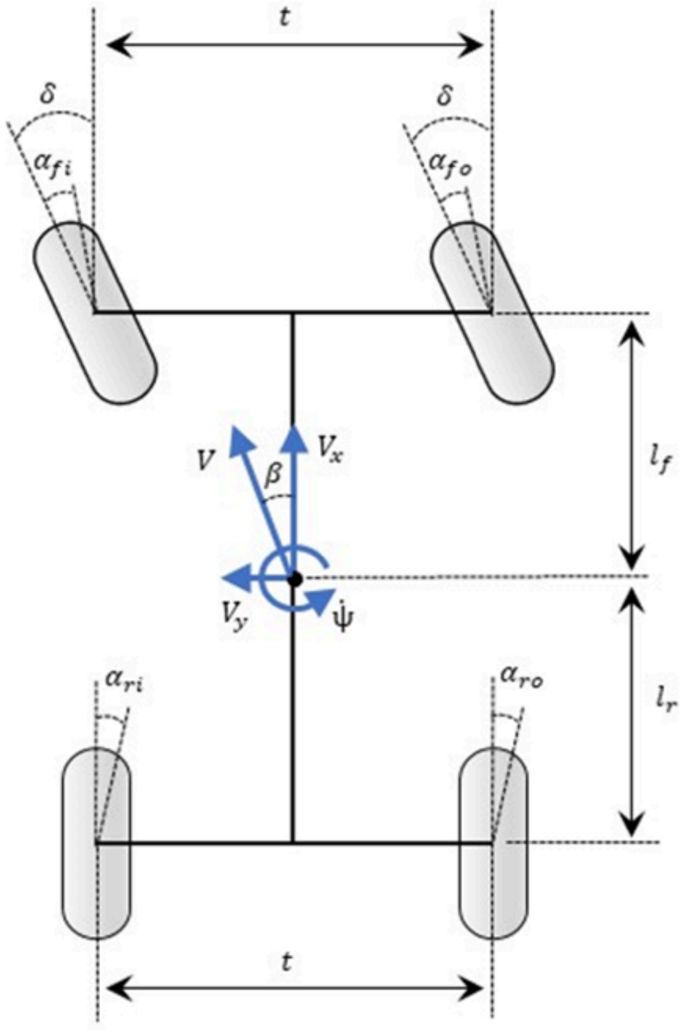
#2 Race-car dynamics

Expected Time: 10 min

Question:
Your racecar is performing a steady-state corner with 8 metres radius at a speed of 10.2 m/s. The vehicle has a longitudinal weight distribution of 50% front / 50% rear, parallel steering (0% ackermann), and 0.5 degrees rear wheel toe in (per rear wheel). Knowing that the slip angle of the rear inside wheel is 4.6 degrees (consider slip angle positive when wheel points to the left of its velocity vector), how much toe is needed on the front wheels to ensure that these have equal slip angles ($\alpha_{fi} = \alpha_{fo}$)? The wheelbase equals the minimum allowed wheelbase according to the Formula Student Rules 2026.

Consider the track width t = 1.2 m and steering angle δ = 12 deg

Toe in is considered positive, toe out is considered negative. Assume rigid-body planar kinematics in steady-state cornering, no roll, no compliance steer.



Answer format: Do not round any intermediate results. Provide your answer in deg and follow the sign convention “-” for toe out and “+” for toe in. Use the following format: +12.34 or -1.23 (no ',' comma, no letters), round final result to 2 decimal places.

Answer: -0.46

Resolution:

$$\dot{\psi} = \frac{velocity}{radius} = \frac{10.2}{8} = 1.275\frac{rad}{s}$$

$$Vx_{RI} = Vx - \dot{\psi} * \frac{t}{2} = 9.435\frac{m}{s}$$

$$Vy_{RI} = -tan(\alpha_{RI} + toe_{rear}) * Vx_{RI} = -tan(5.1°) * 9.435 = 0.84205\frac{m}{s}$$

$$\alpha_{FI} = \delta - atan(Vy_{FI}/Vx_{FI}) - toe_{front}$$

$$\delta = 12°$$

$$Vy_{FI} = Vy_{RI} + \dot{\psi} * WB = -tan(5.1°) * 9.435 + 1.275 * 1.525 = 1.102\frac{m}{s}$$

$$Vx_{FI} = Vx_{RI} = 9.435\frac{m}{s}$$

$$\alpha_{FI} = 12° - atan(1.102/9.435) - toe_{front}$$

$$\alpha_{FI} = 5.338° - toe_{front}$$

$$\alpha_{FO} = \delta - atan(Vy_{FO}/Vx_{FO}) + toe_{front}$$

$$Vy_{FO} = Vy_{FI} = 1.102\frac{m}{s}$$

$$Vx_{FO} = V_x + \dot{\psi} * \frac{t}{2} = 10.965\frac{m}{s}$$

$$\alpha_{FO} = 12° - atan(1.102/10.965) + toe_{front}$$

$$\alpha_{FO} = 6.261° + toe_{front}$$

$$\alpha_{FI} = \alpha_{FO} => 5.338° - toe_{front} = 6.261° + toe_{front}$$

$$toe_{front} = -0.46°$$

#3 Driver Restraint System

Expected Time: 3 min

Question:
A Formula Student team is presenting their vehicle for Technical Inspection. The driver is sitting in the vehicle with a reclined seat back angle of 35° from the vertical. They are using a HANS III (30-degree model) device.
Which of the following configurations would lead to a failure at Technical Inspection according to the FS 2026 Rules?

A) The driver is wearing a helmet labeled with SFI 31.1/2020 and a 6-point harness with 50 mm (2 inch) wide shoulder straps. The FHR device is labeled with SFI 38.1.

B) The team’s head restraint (padding) is a single piece measuring 150 mm x 150 mm with a thickness of 40 mm. When the driver is in a normal driving position, the back of their helmet is 20 mm away from the padding.

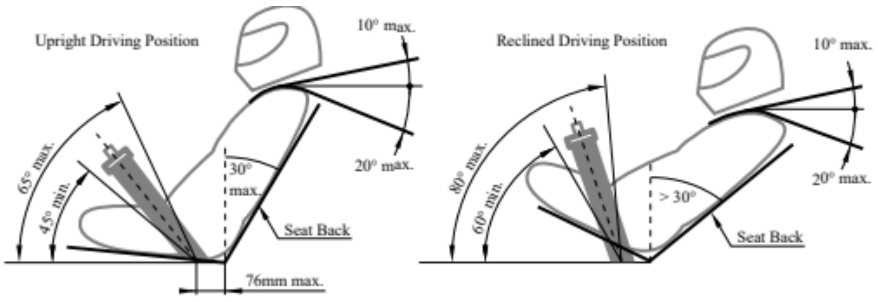
C) The Lap belts are angled 35° rearwards from the vertical as they go down.

D) When the 95th percentile male template (Percy) is placed in the vehicle, the horizontal plane from the contact point of the upper 300 mm circle with the headrest is positioned exactly 250 mm from the center of the middle 200 mm circle (representing the shoulders).

Answer format: Multiple choice

Answer: C)

Resolution:

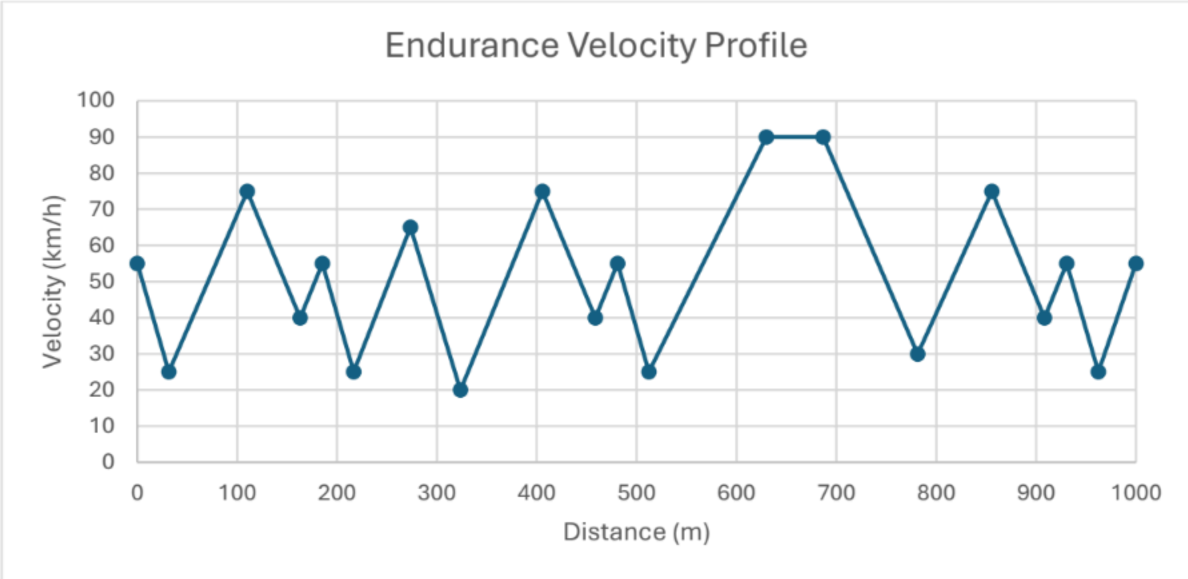


For the reclined driver position (seat back angle >30° from the vertical) the lap belt has to be angled between 60° and 80° to the horizontal which is between 10° and 30° to the vertical.
Remark: there is no restriction for the angle of the “neck” of the Percy, therefore the distance between the horizontal plane as described in D) and the center of the 200 mm circle, can be below 280 mm.

#4 Endurance lap time

Expected Time: 8 min

Question:
You are completing an endurance run in which each lap is exactly 1 km long. The car’s speed along the lap is defined by a sequence of 20 consecutive speed setpoints (in km/h), ordered by distance from the start line:



Below are the velocities (in km/h) at each datapoint:

55	25	75	40	55	25	65	20	75	40	55	25	90	90	30	75	40	55	25	55

Assume the car transitions between each consecutive pair of setpoints using:
• Constant acceleration of 0.25 g when speed is increasing;
• Constant deceleration of 0.30 g when speed is decreasing;
Assume each setpoint represents a point along the distance axis (i.e., the lap is made up only of these constant-acceleration/deceleration segments between consecutive setpoints), and ignore any additional dwell time at the setpoints.

1) What is the total lap time in seconds?
2) What is the average lap speed in km/h?

Use g=9.81m/s^2.

A) Lap time of 70.8s; Average lap speed of 50.85 km/h
B) Lap time of 68.5s; Average lap speed of 52.54 km/h
C) Lap time of 62.4s; Average lap speed of 57.69 km/h
D) Lap time of 71.3s; Average lap speed of 50.49 km/h
E) Lap time of 70.8s; Average lap speed of 47.95 km/h
F) Lap time of 68.5s; Average lap speed of 49.56 km/h
G) Lap time of 62.4s; Average lap speed of 54.41 km/h
H) Lap time of 71.3s; Average lap speed of 47.62 km/h

Answer format: Multiple choice

Answer: A)

Resolution:

Total acceleration time:

$$a_+ = 2.45\frac{m}{s^2}$$

$$a_- = -2.94\frac{m}{s^2}$$

$$t_{acc} = \sum\frac{v_i - v_{i-1}}{a_+} + \sum\frac{v_i - v_{i-1}}{a_-} = 68.52\ s$$

Total distance covered during acceleration/deceleration:

$$x_{acc} = \sum\frac{v_i^2 - v_{i-1}^2}{2 \cdot a_+} + \sum\frac{v_i^2 - v_{i-1}^2}{2 \cdot a_-} = 943.07m$$

Remaining distance at 90 km/h: $x_{90} = x_{tot} - x_{acc} = 1000 - 943.07 = 56.93m$

Additional time: $t_{add} = \frac{x_{90}}{v_{90}} = \frac{56.93}{90} \cdot 3.6 = 2.28s$

$$t_{tot} = t_{acc} + t_{add} = 68.52 + 2.28 = 70.8s$$

$$v_{av} = \frac{x_{tot}}{t_{tot}} = 50.8\frac{km}{h}$$

#5 Car balance

Expected Time: 4 min

Question:

Your driver weighs 75 kg at the moment. You want a neutral steering during Skidpad at the competition. How many kg does the driver need to loose until the competition?

The Formula Student car completes a skidpad lap time of 4.2 s. Use the average skidpad diameter from the FS rules (driving path is between inner and outer circles) to determine its speed.

The car has:

- Mass without driver: 230 kg
- Static rear weight distribution (car only): 51% rear
- Driver CG location (independent of driver mass): 710 mm from the front axle
- Wheelbase: minimum allowed by FS rules

Assumptions:

- Linear bicycle model, small slip angles, steady-state cornering
- No load transfer
- No aerodynamic forces
- Same tires front and rear
- Cornering stiffness is constant and does not depend on normal load

Answer format: Do not round any intermediate results. Provide your answer in kg. Use the following format: 12.34 or 1.22 (no ',' comma, no letters), round final result to 2 decimal places.

Answer: 8.19

Resolution:

The linear bicycle-model neutrality condition reduces to:

$$a = b$$

(where a is CG distance from front axle, b from rear axle, and $a + b = L$)

So:

$$a = b = \frac{L}{2}$$

Meaning: neutral steer ⇔ total CG at mid-wheelbase.

$$x_{\text{target}} = \frac{L}{2} = \frac{1.525}{2} = 0.7625\ \text{m}$$

Car-only rear weight distribution is 51% rear, so car-only CG from the front axle is:

$$x_c = 0.51\,L = 0.51 \cdot 1.525 = 0.77775\ \text{m}$$

Total CG:

$$x_{\text{tot}} = \frac{m_c x_c + m_d x_d}{m_c + m_d}$$

Set $x_{\text{tot}} = x_{\text{target}} = L/2$**:**

$$\frac{m_c x_c + m_d x_d}{m_c + m_d} = \frac{L}{2}$$

Solve for m_d**:**

$$m_c x_c + m_d x_d = (m_c + m_d)\frac{L}{2}$$

$$m_d\left(x_d - \frac{L}{2}\right) = m_c\left(\frac{L}{2} - x_c\right)$$

$$m_d = m_c\,\frac{\frac{L}{2} - x_c}{x_d - \frac{L}{2}}$$

Final answer

$$\boxed{\Delta m_d = m_{d_{ref}} - m_d = 75 - 66.81\ \text{kg} = 8.19\ \text{kg}}$$

EV-Specific Questions

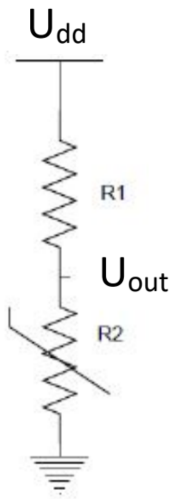
#6 AMS configuration

Expected Time: 2min

Question:

You are configuring the AMS of your car to fully comply with the formula student rules.

The datasheet of the cells in your accumulator specifies a maximum of 4.2 volt and 70° Celsius. You implement a temperature measurement as shown in the figure.



In your implementation U_{dd} = 5 V, R1 = 50Ω ±10% and R2 is a PTC. According to the datasheet of R2 the resistance is 90Ω ±10% for 50° Celsius and 100Ω ±10% at 60° Celsius.

What is the maximum U_{out} voltage that guarantees no AMS trigger?

A) 3.10 V

B) 3.44 V

C) 3.55 V

D) 3.64 V

Answer format: Multiple Choice

Answer: A)

Resolution:

$$U_{out} = \frac{R_2}{R_{tot}} * U\_dd$$

According to FS-Rules EV5.8.4 the maximum allowed cell temperature is 60 °C.

The nominal Value of R_2 at 60°C is 100 Ω. With the temperature resistance being a PTC, meaning the resistance increases with the temperature, a higher resistance means a higher temperature. Therefore, in the worst case, when the 10 % tolerance decreases the resistance of the thermistor, a resistance of 90 Ω can actually mean 60° Celsius.

For the R_1 resistance, the worst-case scenario is 55 Ω as the higher resistance will decrease the voltage on V_{out}.

$$U_{out} = \frac{90}{90 + 55} * 5 = 3.10\ V$$

#7 Endurance energy requirement

Expected Time: 10 min

Question:
A Formula Student vehicle with a total mass of 268 kg (incl. driver) completes the Endurance event consisting of 22 laps of exactly 1 km each. Determine the minimum accumulator energy required at the start of the event, given the following assumptions:

- For the purpose of evaluating the aerodynamic drag and downforce assume the vehicle travels at a constant velocity of 55 km/h throughout the Endurance.
- Air density is ρ = 1.2 kg/m3;
- Frontal area A = 1.1 m2;
- Drag coefficient cd = 1.3;
- Lift coefficient cL = -4.5.
- Tire losses can be modelled as a constant linear friction force with coefficient of friction μR = 0.05.
- No regenerative braking is available.
- Use g=9.81m/s2;
- Neglect elevation changes and auxiliary electrical loads; assume straight-line energy balance only.
- During each lap, the following braking events occur, with all kinetic energy losses fully dissipated:
  - 1 × 90 → 30 km/h
  - 3 × 75 → 40 km/h
  - 4 × 55 → 25 km/h
  - 1 × 65 → 20 km/h
- Neglect the car acceleration at the start of the endurance and the braking/accelerating due to the driver change;
- The overall powertrain efficiency from accumulator to wheel output is constant at 69%.
- At the end of the Endurance, the accumulator state of charge must be ≥ 10%.

Answer format: Do not round any intermediate results. Provide your answer in kWh. Use the following format: 12.3 or 1.23 (no ',' comma, no letters), round final result to 3 significant digits.

Answer: 6.93

Resolution:

$$E_{Aero} = x \cdot \frac{1}{2} \cdot \rho_{air} \cdot c_d \cdot A_S \cdot v_{av}^2 = 22000 \cdot 0.5 \cdot 1.2 \cdot 1.3 \cdot 1.1 \cdot \left(\frac{55}{3.6}\right)^2 = 1.22\ kWh$$

$$F_z = m \cdot g + \frac{1}{2} \cdot \rho_{air} \cdot c_L \cdot A_S \cdot v_{av}^2 = 268 \cdot 9.81 + \frac{1}{2} \cdot 1.2 \cdot 4.5 \cdot 1.1 \cdot \left(\frac{55}{3.6}\right)^2 = 3322\ N$$

$$E_{Tire} = \mu_R \cdot F_z \cdot x = 0.05 \cdot 3322 \cdot 22000 = 1.01\ kWh$$

$$E_{Brake} = \sum n \cdot \frac{1}{2} \cdot m \cdot (v_1^2 - v_2^2) = 2.07\ kWh$$

$$E_{loss_1} = E_{Aero} + E_{Tire} + E_{Brake} = 4.30\ kWh$$

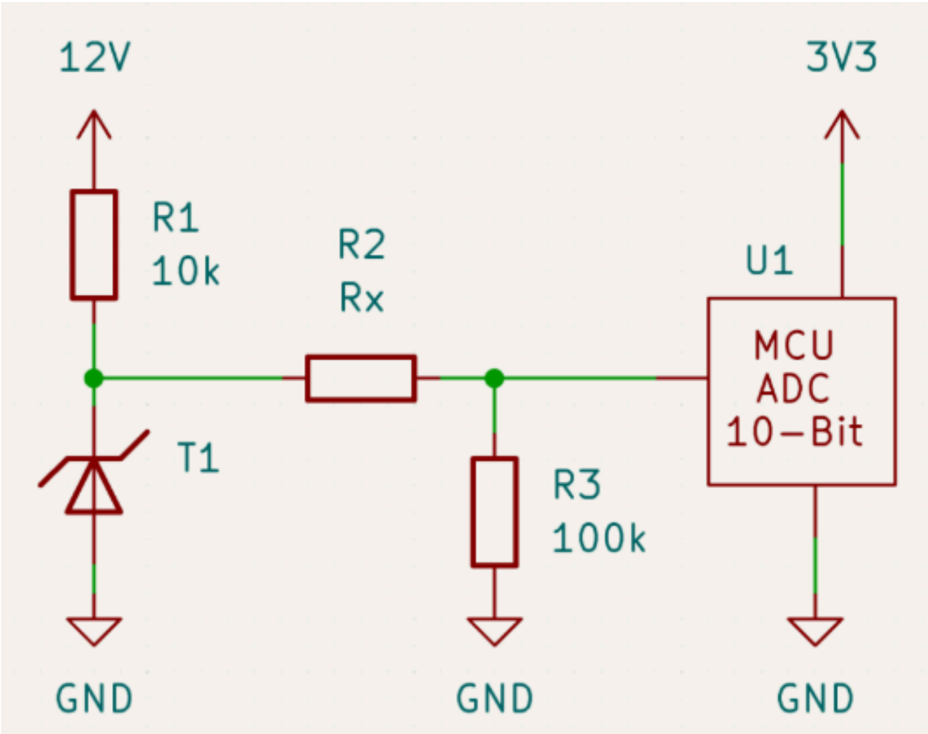
$$E_{PT} = E_{loss_1} \cdot \frac{1 - \eta_{PT}}{\eta_{PT}} = 1.93\ kWh$$

$$E_{min} = \frac{1}{1 - SOC_{End}} \left(E_{PT} + E_{loss_1}\right) = 6.93\ kWh$$

#8 Accumulator temperature measurement

Expected Time: 2min

Question:
For temperature measurement within the accumulator, the LM135 temperature sensor is used in the schematic shown below. The microcontroller used has a 10-bit ADC resolution and is supplied with 3.3 V. The circuit is designed to measure the range from −55 °C to 150 °C.



If the analog value increases by one bit, what temperature change must the temperature sensor have measured compared to the previous value?

Consider the LM135 temperature sensor has a linear sensitivity of 10mV/K.

Answer format: Do not round any intermediate results. Provide your answer in K. Use the following format: 12.345 or 1.234 (no ',' comma, no letters), round final result to 3 decimal places.

Answer: 0.413

Resolution:

https://www.ti.com/lit/ds/symlink/lm135.pdf

To arrive at the correct result, two approaches are possible. The shorter method is shown below. The following information is important from the datasheet:

- Directly calibrated to the kelvin temperature

- The voltage is directly proportional to the absolute temperature at 10mV/K

- Operating Output Voltage: 2.98 V @ 25°C

Calculation:

As described in the datasheet, the voltage characteristic is directly proportional to temperature in kelvin, which can also be seen from the following calculation:

2.98 V @ 25°C 2.98 V @ 273 K + 25° = 2.98 V @ 298 K

It can be stated that 0 V @ 0 K

Since the maximum temperature is 150 °C, this corresponds to the maximum possible ADC value.

150 °C uses 10-Bit

Due to the lack of specification of the number of digits to be used in the conversion from ºC to K, two results are accepted.

150 °C + 273 K = 423 K

$$\frac{423K}{1023\,Bit} = 0.413\,K/Bit$$

150 °C + 273.15 K = 423.15 K

$$\frac{423.15K}{1023\,Bit} = 0.414\,K/Bit$$

#9 Maximum current

QUESTION DELETED!
Unclear sensor selection criteria.

Expected Time: 3 min

Question:
A rules-compliant accumulator consists of 12 stacks in series, each configured as 12s4p. The current within the accumulator is monitored by a Hall sensor directly connected to a microcontroller with 12-bit resolution.

What is the maximum possible input value read by the microcontroller at the moment when maximum power is drawn, assuming the accumulator is charged to its nominal voltage and the ambient temperature is 25 °C?

Datasheet: Current Transducer HASS 50 ... 600-S (V22):

https://www.lem.com/sites/default/files/products_datasheets/hass-50_600-s-v22.pdf

Consider the following:
Choose the smallest LEM HASS XXX-S range such that the sensor does not saturate at the maximum current.
Cell characteristics:

CELL CHARACTERISTICS

Capacity	Nominal	2,000 mAh 7.4 Wh
Cell Voltage	Nominal Charge Discharge	3.7 V 4.2 V 2.5 V
Continuous Charge Current	Standard Maximum	1.0 A 6.0 A
Charge Time	Standard Fast Charge	180 min 40 min
Continuous Discharge Current	Maximum	30 A
Internal Resistance	AC (1 KHz)	≤20 mΩ
Operating Temperature	Charge Discharge	0°C to 50°C -20°C to 80°C
Energy Density	Volumetric Gravimetric	435 Wh/L 160 Wh/kg

The internal reference voltage for the analog digital conversion is 3.3 V.

Answer format: Do not round any intermediate results. Provide your answer in units. Use the following format: 12 or 1 (no ',' comma, no letters), round final result to 0 decimal places.

Answer: 3617

Resolution:

Max. current see characteristics.

Imax=120A

HASS 200-S is the choice because of the current range

https://www.lem.com/sites/default/files/products_datasheets/hass-50_600-s-v22.pdf

Analog output voltage (see datasheet HASS)

$$U_{out} = U_{OE} \pm \left(0.625 * \frac{I_P}{I_{PN}}\right) = 2.5\,V \pm 0.025 \pm 0.015 \pm \left(0.625 * \frac{120\,A}{200\,A}\right) = 2.5\,V \pm 0.415 = 2.915\,V$$

Resolution ADC (12 Bit = 2^{12}):

$$X = \frac{2.915\,V}{3.3\,V} * 4095 = 3617.25 \rightarrow \mathbf{3617}$$