FSN Registration Quiz 2024

Question 1: (both classes)

An FS race vehicle is entering a drag strip with an infinite strip length.

It has a motor with a maximum rotational speed of 10500rpm at 70kW and a final gear reduction of 7.8. The motor to wheel power delivery efficiency is 61% and the wheel diameter is 0.4m

The aero drag coefficient is equal to C_d*A=1.5m^2, while the density of the air is considered equal to 1.2 kg/m^3.

The friction losses from tires, bearings etc can be modeled with the following equation: $F_{friction}$=$1.4 * V^2$, where V is vehicle speed in m/s

What is the maximum speed that can be reached by that vehicle?

A) 61.91 km/h
B) 112.39 km/h
C) 95.32 km/h
D) 101.49 km/h

Explanation:
The maximum speed is governed either by the maximum rotating speed of the motor or the maximum speed due to the forces acting on the vehicle due to power limitations.

1) Maximum speed from the motor

Max rotating=10500rpm

Gear ratio=7.8

Wheel diameter= 0.4m

$$\omega_{wheel} = \frac{\omega_{motor}}{gear_{ratio}} = \frac{rpm_{motor} * \mathbf{0.10472}\frac{\boldsymbol{rad}}{\boldsymbol{s}}}{gear_{ratio}} = \mathbf{140.96}\ \boldsymbol{rad/s}$$

$$u = \omega * R = 140.96 * 0.2 = 28.192\frac{m}{s} = 101.49\frac{km}{h}$$

2) Maximum speed due to external forces and power limitations

$$Power = Power_{maximum} * efficiency = 70000 * 0.61 = 42700W$$

$$(F \quad + F_{aero}) * V = Power_{needed}$$

$$(1.4 * V^2 + 0.5 * \rho * C_d * A * V^2) * V = Power_{needed}$$

$$(1.4 * V^2 + 0.9 * V^2) * V = Power_{needed}$$

$$V = \sqrt[3]{\frac{Power_{needed}}{2.3}} = 26.48\,m/s = 95.32km/h$$

Thus, the maximum speed is the power limited rather than motor speed limited, 95,32km/h .

Question 2: (both classes)

What will Young's Modulus be for a 10 mm square bar and with a length of 400mm when it lengthens by 3 mm under a load of 100 kN?

a) 101.87 GPa.

b) 85.46 GPa.

c) 133.33 GPa.

d) 210.48 GPa.

Explanation:

$$\boldsymbol{E = \frac{\sigma}{\varepsilon} = \frac{\frac{F}{A}}{\frac{dl}{L}} = \frac{\frac{100kN}{10 * 10mm^2}}{\frac{3}{400}} = 133,33\ GPa}$$

Question 3: (both classes)

Which material is suited as a protective cover for a cooling hose of a cooling system using plain water and runs through the monocoque under the driver`s legs?

a) Aluminum sheet with holes smaller than 25 mm diameter.

b) Aluminum sheet without any holes.

c) There is no need for any protective cover.

d) Aluminum grid with a minimal spacing of 2 mm between the strings

Explanation:

T7.2.3 Cooling systems using plain water (except outboard wheel motors and their cooling hoses) must have a heat resistant (Permanently rated for at least 100 °C), rigid and rigidly mounted cover which covers any part of the tallest driver below a plane 100 mm above the bottom of the helmet.

Question 4: (both classes)

A team finds a new supplier to buy some new belts, which of the following is an appropriate solution?

A) A 6-point system with 2 lap belts of 55mm width, 2 anti-submarine belts of 50mm width and 2 shoulder straps of 70mm width, that passes FIA specification 8853/2016

B) A 7-point system with 2 lap belts of 55mm width, 3 anti-submarine belts of 50mm width and 2 shoulder straps of 70mm width, that passes SFI Specification 16.1

C) A 7-point system with 2 lap belts of 55mm width, 3 anti-submarine belts of 50mm width and 2 shoulder straps of 50mm width, that passes FIA specification 8853/2016, with the use of a HANS device.

D) A 6-point system with 2 lap belts of 50mm width, 2 anti-submarine belts of 50mm width and a ‘Y’-type shoulder strap of 75mm width, that passes FIA specification 8853/2016

Explanation:

T5.1.1 6-point system – consists of a two-piece lap belt (minimum width 50 mm), two shoulder straps (minimum width 75 mm) and two leg or anti-submarine straps (minimum width 50 mm).

T5.1.2 7-point system – same as the 6-point system except it has three anti-submarine straps.

T5.1.3 upright driving position – position with a seat back angled at 30° or less from the vertical as measured along the line joining the two 200 mm circles of the 95th percentile male template as defined in T 4.3 and positioned per T 4.3.4.

T5.1.4 reclined driving position – position with a seat back angled at more than 30° from the vertical as measured along the line joining the two 200 mm circles of the 95th percentile male template as defined in T 4.3 and positioned per T 4.3.4

T 5.2 Belts - General

T5.2.1 All drivers must use a 6-point or 7-point restraint harness meeting the following specifications:

- All driver restraint systems must meet SFI Specification 16.1, SFI Specification 16.5, SFI Specification 16.6 or FIA specification 8853/2016.
- The belts must bear the appropriate dated labels.
- The material of all straps must be in perfect condition.
- There must be a single metal-to-metal latch type quick release for all straps.
- All lap belts must incorporate a tilt lock adjuster ("quick adjuster"). A tilt lock adjuster in each portion of the lap belt is highly recommended. Lap belts with "pull-up" adjusters are recommended over "pull-down" adjusters.
- Vehicles with a "reclined driving position" must have either anti-submarine belts with tilt lock adjusters ("quick adjusters") or have two sets of anti-submarine belts installed.
- The shoulder harness must be the "over-the-shoulder type". Only separate shoulder straps are permitted (i.e. "Y"-type shoulder straps are not allowed). The "H"-type configuration is allowed.
- The shoulder harness straps must be threaded through the three bar adjusters in accordance with the manufacturer's instructions.
- When a HANS device is used by the driver, FIA certified 50 mm wide shoulder harnesses are allowed.

Question 5: (both classes)

Which of the following is not correct about the Front Hoop Bracing?

A. The minimum wall thickness for the steel tube used for Front hoop bracings must be 1.2mm.

B. Front hoop bracing may be used with bends if provided with additional support structure.

C. If front hoop is inclined more than 10 degrees then additional bracing support is needed extending rearwards.

D. The front hoop bracing structure must be attached no lower than 50 mm below the top-most surface of the front hoop.

Explanation:
T3.11.1

Question 6: (both classes)

What is true about jacks?

A. **A driver must be able to enter the vehicle in a lifted position**
B. Using their jack(s), a team must be able to lift any wheel at least 100mm from the ground
C. Pick-up points must be marked with red triangles
D. Only team members named Jack may operate a jack

Explanation: T13.2

Question 7: (CV Class)

If a full cylinder has a Moment of Inertia of J = 1,08 kg/m^2, what is the Moment of Inertia of a full cylinder with the same mass but half the diameter?

A. 0.16 kg/m^2
B. 0.84 kg/m^2
C. 0.73 kg/m^2
D. **0.27 kg/m^2**

Explanation:

The moment of inertia of cylinder is $J = \frac{1}{2} * m * R^2$

$$J_1 = \frac{1}{2} m * \left(\frac{D_1}{2}\right)^2 = 1.08 \frac{kg}{m^2}$$

$$J_2 = \frac{1}{2} m * \left(\frac{D1}{4}\right)^2$$

$$\frac{J_1}{J_2} = \frac{\frac{1}{2} m * \left(\frac{D_1}{2}\right)^2}{\frac{1}{2} m * \left(\frac{D1}{4}\right)^2} = \frac{\frac{D_1^2}{4}}{\frac{D_1^2}{16}} = 4 \rightarrow J_2 = \frac{J_1}{4} = \frac{1.08}{4} = 0.27 \frac{kg}{m^2}$$

Question 7: (EV Class)

You decided to implement a RTOS (real time operating system) in your VCU (vehicle control unit) in this season. The table on the right side shows the implemented tasks with their priorization (lower priority is executed preferrebly). ISRs (interrupt service routines) are not covered by the task manager of the RTOS and always overrule a task.

Task Name (Function)	Cycle Time	Exec. Time	Prio
Motor Control	500	60	1
Sensor Evaluation	1	50	2
Communication	10	40	2
Power Management	10	20	2

You are using a single watchdog timer with a period of 650 µs.

You're using the pump speed to calculate a coolant flow rate, which is shown in the cockpit display. As there is no dedicated sensor for evaluation of the pump speed, you connected the pumps PWM feedback signal to a capture/compare timer input that triggeres an ISR. To prevent implausible values, the monitoring is only active if the pump is turned on by the power management.

The code was written by another team member and handed over to you for testing. During commissioning of the vehicle, watchdog timeouts occur whenever the pump is activated.

You also notice, that the display is only partly redrawn when the watchdog is triggered. Without being asked, your team mates provide their analysis and solutions.

A) Try to reduce the cycle time of the sensor evaluation task
B) The display is updated in the ISR, which blocks other tasks and the watchdog reset
C) Incoming CAN messages interrupt the sensor evaluation so the communication task should get lower priority (increase the number)
D) Pause the watchdog during the pump monitoring or increase the timer period

Which idea you should investigate further? (still consider good practice and security)

a) A
b) B
c) C
d) D

Explanation:

Answer b) is correct, only the proposal B) is a plausible explanation. The others are either bad practice or wrong measures even if the failure scenario is correct.

The watchdog is a timer with a period equal to the fastest tasks cycle time plus its estimated maximum execution time. The timer is usually reset at the end of the fastest task execution.

If the reset doesn't happen, the ISR of the timer is triggered which results in a watchdog timeout.

As the motor control task is the most critical one (shortest cycle time and highest priority, except for watchdog), the watchdog reset is done here. If the watchdog reset is implemented correctly, a timeout can only occur, if something interrupts the motor control task.
Consequently, only an ISR is capable of blocking the watchdog reset and cause a timeout. Another possible scenario would be, if the execution of the motor control task is taking too long. However none of the provided tips is pointing in this direction.

The capture/compare timer input (for pump speed evaluation) is usually connected to an ISR. Common or good practice for such an application is to evaluate the PWM signal inside the ISR, save the value (e.g. duty cycle) to a global variable and process it outside of the ISR.

Even the calculation of a flow rate inside the ISR would not take too much computation time but maybe require additional data from other software modules (e.g. information about the cooling ciruit) which may result in less data encapsulation and therefore is considered bad practice.

A display update is usually done via sendig signals on a bus (like UART, I2C or SPI) to the display. Depending on the display, its resolution and other parameters, this can take quite a lot of messages to transfer all the information to the display.
Furthermore, parameters like the bus speed or timing requirements may further increase the needed time.

If all these actions are done in the ISR, this may block the motor control task from execution too long to reset the watchdog timer before the timeout happens.

Question 8: (CV Class)

Which of the following statements about the Fuel System is correct?

A. **The fuel tank can be made of flexible material.**
B. The fuel tank must not be located within the surface envelope.
C. The fuel tank must be securely attached to the vehicle structure with mountings that do not allow flexibility such that chassis flex cannot unintentionally load the fuel tank.
D. The fuel tank must only be made of a rigid material to prevent failure under loading.

Explanation:

(CV2.3.1)

Question 8: (EV Class)

The datasheet of the the cells in your accumulator specifies a maximum of 4.2 volt and 55°Celsius. You implement a temperature measurement as shown in the figure. In your implementation Vdd equals 5 Volt, R1 is of 50Ω with 10% intolerance and R2 is a PTC. According to the datasheet of R2 the resistance is 92Ω for 50°Celsius and 108Ω at 60°Celsius with a 5% intolerance. What is the maximum voltage you are allowed to measure on Vout rounded to two decimal places without triggering an AMS error? You may use linear interpolation.

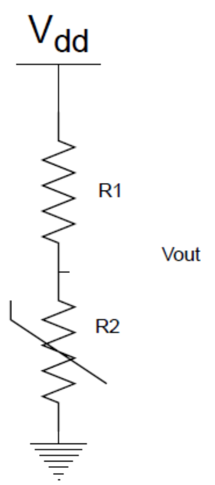

Figure 1: Temperature measurement circuit

A 3.11 Volt

B 3.16 Volt

C 3.28 Volt

D 3.33 Volt

Explanation:

As linear interpolation may be used, the value of R2 at 55°Celsius is 100Ω as that is the middle of 92 and 108 ($92 + \frac{(108-92)}{2} = 92 + \frac{16}{2} = 92 + 8 = 100$).

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 5% intolerance decreases the resistance of the thermistor, a resistance of 95Ω actually means 55°Celsius.

Same holds for the R1 resistance where the worst case scenario is 55Ω as the higher resistance will decrease the voltage on Vout.

Now with the standard formula for a voltage divider the maximum allowed voltage is $\frac{R2}{R1+R2} \cdot 5 = \frac{95}{95+55} \cdot 5 = \frac{95}{150} \cdot 5 \approx 3.1667$ Volt. As the maximum voltage on Vout is required, it is not allowed to round up as that would go over the limit. Therefore, the maximum voltage measured on Vout for triggering an AMS error is 3.16 Volt, answer B.

Question 9: (both classes)

You must submit a DBOM for FSN2024, for which system?

A. Steering System
B. Engine and Drivetrain
C. Brake System
D. Suspension System

Explanation: FSN Competition Handbook NL3.16

Question 10: (both classes)

The Technical Inspection Order at FSN2024 is based on what factor?

A. VSV Submission Date
B. Registration Quiz Result
C. Random Draw
D. Position on WRL

Explanation: FSN Competition Handbook NL4.1