Bonus Test 1

Q1
You are designing a navigation satellite for the Galileo system. You have estimated for this satellite a S/C dry mass of 800kg. Using the data from SMAD, page 894, you are asked to provide an estimate for propellant mass (in kg).
52.0 kg
[Given; 48.8, 44.1, 374]

Q2
A spacecraft of 500 kg mass and with a frontal area of 2 m^2 is in circular orbit about Earth @ 350 km altitude. Determine for this spacecraft the maximum drag force (solar max) in case this spacecraft has a drag coefficient of 2.
1.97 mN
[Given; 1.1N, 0.43N, 4.3N]

Q3
Which kind of structure or structural part is sensitive to acoustic loads? (Multiple answers possible)
Antenna reflector dish
[Given; Equipment boxes, Solar array panels]

Q4
You are in charge of designing a S/C. For this S/C you have estimated a mass of 4000 kg. Of these you have distributed 3200 kg over the 6 subsystems (20% is kept in reserve). Your engineers have estimated subsystem mass as well as the standard error of the estimate. For each of the subsystems 1-3 this is 6% of the vehicle mass of 4000 kg. For each of the subsystems 4-6 this is 18% of the vehicle mass. Total subsystem mass estimated is 3198 kg. What is the standard error (in %) of the sum of the subsystem masses? You may assume that the individual estimates are independent from each other.
32.9
[Given; no answer possible without further information, 41.2% 12%]

Q5
The terms 'set point' and 'dead band' apply to which component present in a Spacecraft?
Thermostat
[Given; Heater, Radiator, Battery]

Q6

To which class does a satellite belong if the satellite has a total mass of 768 kg?

Class 1: Large satellite
Class 2: Small satellite
Class 3: Mini satellite
Class 4: Micro satellite
Class 5: Nano satellite
Class 6: Pico satellite

Answer by filling in the number of the class, for example 1, 2 or 3.

1

(side note; Large >1000kg, Medium 500-1000, mini 100-500, micro 10-100, nano 1-10, pico 0.1-1, femto <100g, [Small satellites include all from mini-femto]).

Q7

You have estimated a dry spacecraft mass of 1000kg and a total electrical power of 3000W. S/C mass density is 100kg/m^3. Launcher available diameter is 3m. To provide for electrical power you have decided for an 3-axis stabilized vehicle equipped with two solar array wings (one on each side of the S/C) of identical size and with the array panel height identical to the S/C height. Determine the length of a single such wing.

6.5

[Given; 13, 12.7, 3.9]

Q8

Calculate the natural frequency of a simple beam for lateral vibrations using the following properties:

Tip mass = 5 kg

E = 69 GPa

I = 0.00020 m^4

Length = 2 m

162Hz

[Given; 523, 1099, 619]

Q9

Consider the bus as described in the problem 1.7 from the problem book. Using the data from the problem description, you are asked to determine the total power (in Watt) that should be generated by the electrical power generation subsystem of the bus.

7751.94

Q10

You are in charge of designing a S/C. For this S/C you distinguish 8 different subsystems. Your engineers have produced a most likely estimate for the mass of these subsystems. They also have computed a standard error for the estimates. For the systems 1-4 this is 5% of the subsystem mass and for the systems 5-8 this is 10%. What is the standard error (in %) of the sum of the subsystem masses? You may assume that the individual estimates are independent from each other.

22.36%

[Given; (60/8)%, 60%, cannot be answered without further information.]

Q11

A plate with dimensions 3.5 x 10 cm is in deep space. The plate has a 2 mil Aluminized Teflon coating. The temperature of the plate is 114 degrees Centigrade.
How much heat will the aforementioned plate radiate?
Give the answer in Joules.

5.876

Q12

A deep space probe with a mass of 1000 kg and a heat capacity of 900 J/kg-K is exposed to the Sun during most of its journey. Given that the spacecraft area exposed is constant and equal to 2 m^2 and that the Sun's heat input on average is 1300 W/m^2, calculate the rise in spacecraft temperature (in K) resulting in case the spacecraft is exposed to the Sun for a period of 5 days in a row without any means of cooling applied.

1248

Q13

You have decided for a S/C with a rectangular box-shaped body. This body is of size 2.6 x 2.8 x 2.5 m. The mass of this body is homogeneously distributed with a mass density of 100 kg/ m^3. Determine for this body the maximum Mass Moment of Inertia (MMOI) about the body axes in case we are dealing with an orthogonal centroidal axes system.

2214 kg-m^2

[Given; 1820,1420,2713]

Q14

A Scientific Instrument demands an experiment, enveloped in a sphere. The sphere should have the highest possible temperature, without active heating. The sphere is only illuminated by the sun and radiates to space. What is the ranking of the coatings to create high temperatures? Order from best to worst. The a/e ratio represents the alpha/epsilon ratio

3.	Black (a/e = 0.9/0.85)
5.	Optical Solar reflectors (0.1/0.8)
2.	Aluminium (a/e = 0.15/0.05)
1.	Gold (a/e = 0.25/0.03)
4.	White (a/e = 0.2/0.85)

Q15

A spherical titanium propellant tank with an internal volume of 2 m^3 is subjected to an internal pressure of 20 bar. Calculate for this tank the minimum tank wall thickness (in mm) required given that we intend to proof test all tanks produced before flying them. For the material properties, you may consult SMAD, table 11-52.

Your answer should be correct up to two digits behind the decimal point.

1.09

Q16

Due to the earth's orbit being elliptical, the intensity of the sunlight reaching earth varies by approximately:

3.5%

[Given; 10, 1, 5]

Q17

In designing a cylindrical pressure vessel with spherical heads, the required wall thickness of the cylindrical part exceeds that of the spherical parts.

True

Q18

If you know that the solar constant in Earth Orbit is 1371 W/m^2 and that the planet Mercury has a distance to the sun of 0.4 AU.

The Solar intensity in an orbit around Mercury is ...

8569 W/m^2

[Given; 5484, 3427, 548]

Q19

Thermal Control would be impossible if Spacecraft were black bodies, except perhaps by varying the internal heat dissipation

True

Q20

You have estimated a S/C mass of 1,657 kg. Assuming a homogenous mass distribution, a mass density of 205 kg/m^3, and a cylindrical S/C of diameter 2.53 m, you are asked to determine the MMOI (in $kg\text{-}m^2$) about the cylinder axis.

1325.79

Q21

Factors of Safety are defined

To cover uncertainties

[Given; to increase the mass, to complicate the structural analyses]

Q22

For which one of the following orbits may Albedo be neglected?

GEO

[Given; Sun-synchronous Earth orbits, LEO, and orbit about the EArth provided that we are flying at high altitude]

Q23

The ultimate stress is an important parameter for strength

True

Q24

Given are 4 spacecraft with their respective masses and volumes:

Spacecraft 1: 45 kg and 1 m^3

Spacecraft 2: 100 kg and 2 m^3

Spacecraft 3: 150 kg and 2.5 m^3

Spacecraft 4: 200 kg and 3 m^3

What is the average density for these four spacecraft? Give the answer in kg/m^3.

55.42

Q25

A S/C has to perform various manouevres using a rocket propulsion system. Below the manouevres are given in terms of delta-V (Δv) and the specific impulse (I_{sp}) of the propulsion system used:

- Injection into target orbit: Δv = 1000 m/s, I_{sp} = 300s
- Orbit maintenance: Δv = 200 m/s, I_{sp} = 200s
- De-orbit at EOL: Δv = 250 m/s, I_{sp} = 200s

You have estimated a S/C dry mass of 500 kg. Calculate the initial vehicle mass (dry mass + propellant load). You may assume that $g_o = 10 m/s^2$.

874kg

[Given; 279, 317, 503]

Q26

You have tabulated mass data of 4 spacecraft belonging to one and the same class:

Spacecraft 1: 982 kg

Spacecraft 2: 2,451 kg

Spacecraft 3: 909 kg

Spacecraft 4: 1,805 kg

What is the Sample Standard Deviation (SSD) in kg for the spacecraft mass?

732.49

Q27

You are designing a S/C with a rectangular box-shaped body. This body is of size 2.6 x 2.8 x 2.5 m^3. The mass of this body is homogeneously distributed with a mass density of 231 kg/m^3. Determine for this body the maximum Mass Moment of Inertia (in $kg\text{-}m^2$) about the body axes in case we are dealing with an orthogonal centroidal axes system.

5115.11

Q28

In failure mode, equipment dissipation is:

0

Q29

A 2 m diameter spherical satellite is spinning about its z-axis with 50 RPM. The momentum of inertia about the spin axis is 600 kg-m^2. A thruster pair (= two thrusters) of 10 N each, is mounted on the outside of the sphere in the x-direction with one thruster pointing in the negative x-direction and one thruster pointing in the positive x-direction. How long must the pair of thrusters burn to stop the spinning of the satellite.
157.1s
[Given; 121.3, 194.6, 304.9]

Q30

A satellite with a mass of 100 kg is attached to a rocket via an adapter with a spring constant k = 10^4 N/m. At the moment of rocket engine burn out the satellite experiences a sudden shock. What is the natural frequency (in Herz) of the satellite/adapter assembly if the rocket's mass is much larger than the satellite mass and if there is no damping.

Your answer should be correct up to two digits behind the decimal sign.

1.5915

Quiz 2

Q1

If one uses BPSK R-1/2, K=7 Viterbi Soft DEC with a Energy per bit divided by the noise spectral density (Eb/No) equal to 5 dB, what is the probability of Bit Error?

- ☐ 10^-4
- ☐ 10^-5
- ◉ 10^-6
- ☐ 10^-7

Q2

You are designing the power subsystem of an Earth Observation satellite in Low Earth Orbit (LEO) with an orbital period of 100 minutes (min). The power required by the payloads on board of this satellite is:
- 100W during 80min.
- 50W during 40min.
- 1000W during 10min.

Determine the average power needed per orbit assuming that the spacecraft (S/C) subsystems add 25% to the power used by the payloads.

- ☐ 1150 W
- ☐ 1437.5 W
- ◉ 250 W
- ☐ 143.75 W

Q3

We need to calculate the minimum data rate to transfer Voice PCM (Reader A1 pager 175). We want the maximum quantization error to be 0.1%. We will also add 1 parity bit. Give the data rate in kbps.

80

Q4

You are designing a satellite to ground link for television broadcast operating at 20GHz. The link requires an availability of 99.5% for users that view the satellite at 10 degrees antenna elevation. What is the rain attenuation in dB that you should take into account in your link budget?

10

Q5

One wants the minimum quantization error to be less than 0.5%. What is the minimum number of bits per sample, including parity, which one would have to use? (Parity is 1 bit)

8

Q6
You are designing a planar solar array. You have calculated that the array must provide 1000 Watt of electrical power End Of Life (EOL). For a solar illumination intensity of 1367 W/m^2, a cell efficiency of 15%, an inherent degradation of 0.75 and a solar cell degradation of 2% per year, calculate the size (in meters squared) of the solar array for an average Sun incidence angle of 10 degrees and a 5 year operational life.

- (●) 7.3 m^2
- ( ) 0.65 m^2
- ( ) 6.5 m^2
- ( ) 6.6 m^2

Q7
Given information about a circular antenna:
-The carrier frequency is 2GHz.
-The antenna diameter is 2m.

What is the half-power beamwidth? Give the answer in degrees.
5.25

Q8
Of the following functions, list the ones that are performed by the C&DH system

- [x] On-board time keeping
- [x] Command processing
- [ ] Temperature control
- [x] Telemetry frame generation
- [ ] station keeping

Q9
You have designed an EPS with an array regulator, battery charge & discharge regulator. The efficiencies of the system are:
- Array regulator: 90%
- Electric wiring to the battery: 99%
- Battery charge regulator: 90%
- Battery: 90%
- Battery discharge regulator: 95%
- Electric wiring from battery to the loads: 97%

Calculate the efficiency (as percentage of power generated at the array) of the path from the solar array through the battery to the loads.
0.665

Q10
Which of the following statements are true:

1. Battery capacity changes with discharge rate (i.e. current being drawn from the battery)
2. Lower battery temperature significantly reduces battery capacity
3. How much current a battery delivers is independent of the load resistance
4. The older a battery becomes, the lower will be the capcaity that can be obtained from it
5. A possible unit for battery capacity is Ampere/kg

- [ ] 1,2,4
- [x] 1,3,4
- [ ] 2,3,4
- [ ] 1,4,5

Q11
Pick the functions which a CD&H system carries out

- [x] Time keeping
- [x] Computer Watchdog
- [x] Attitude Control
- [ ] Propulsion
- [ ] None of the above

Q12
You are designing the electric power generation subsystem for a deep space probe. For this probe you have decided you will use RTGs. For most of the time the power needed by the probe is 400W, except that every hour the probe will be in contact with Earth for about 10 minutes (min.). During these contacts the power needed is 1000Watt (W). As RTGs are designed for average output and not peak, the additional power is obtained from a storage device. For a path efficiency of 80% during normal conditions and 60% when drawing power from the storage device, you are asked to determine the average power to be provided (in Watt) by the RTGs.
694.44

Q13
Consider a communications link that has a Bit Error Rate of 5*10^-4. How many bits out of 10,000 bits will be corrupted?
5

Q14
We have a high quality parabolic ground antenna. The radius of the aperature is 1 cm. What is the effective receive antenna aperature area Ar. The efficiency is 0.7.
Give the answer in [cm^2]
2.199

Q15
A frame of 200 bits is being transmitted. If the BER is 2 * 10^-4, what is the probability that the frame arrives with no errors?
0.961

Q16
Consider the following ground station receiver chain;
Antenna - coaxial cable A- Low Noise Amplifier - coaxial cable B - Receiver
The Low Noise Amplifier is placed as close to the antenna as possible in order to:

- [x] Reduce the influence of coaxial cable A
- [ ] Reduce the influence of coaxial cable B
- [ ] Increase the antenna gain
- [ ] Increase the system noise temperature

Q17
You are considering the use of a fuel cell to produce the power for a Mars buggy. This buggy uses 200W of electrical power. Operational life of this buggy is 2 weeks. Determine the amount of reactant (in kg) that must be carried on board of this buggy in case the fuel cell has a reactant consumption of 0.5 kg/kwh.
33.6

Q18
At the subsystem level, the TT&C subsystem interfaces directly with every subsystem except for ....

- [x] Propulsion
- [ ] Power Supply
- [ ] Thermal Control
- [ ] Attitude determination and control

Q19
What is the minimum required
in order to obtain a Bit Error Rate of when using FSK modulation?
12

Q20
Convert 20,000 to dB.
43

Q21
Calculate the required datarate for a voltage measurement on board a spacecraft which requires an accuracy of 0.1V and has to be performed over a range of 0-5V, with a measurement frequency of 10Hz. (One parity bit included)
154

Q22
You have selected wire with gauge number 16 as the size of the electric wiring to provide 150 Watt of electric power to one of the payloads on board of your spacecraft. Bus voltage is 50 V. Wire length is 50 m. Determine the percentage of power loss in the wire.
9.099

Q23
You are designing an RTG for an electric power output of 500W. The thermal to electric conversion efficiency is 8%. Determine for this RTG how much thermal power (in Watt) is to be removed to keep the temperature of the RTG stable.
5750

Q24
The solar array area needed to produce a certain amount of power depends on the lay-out of the solar cells on the vehicle. We distinguish wing-mounted and body-mounted cells. Which of the ratios indicated below gives best the solar cell area ratio between:
- wing-mounted cells (with full tracking of the Sun): A_wing
- body mounted cells on a cylindrical spinning satellite (spin axis perpendicular to the Suns' rays): A_spin, and
- body mounted cells on a free tumbling cubic satellite; A_cube.
Note: Pi = 3.14...

- ☐ A_wing : A_spin : A_cube = 1 : Pi : 2
- ☐ A_wing : A_spin : A_cube = 1 : Pi : 6
- ☐ A_wing : A_spin : A_cube = 1 : 2Pi : 6
- ◉ A_wing : A_spin : A_cube = 1: Pi : 4

Q25
Which of the following characteristics can be considered as an advantage of an external energy source over an internal one?

- ☑ The mass of the power source does not have to be taken into account.
- ☐ The power delivered varies with the distance.
- ☐ The total amount of energy needed does not influence the design of the power system.

Q26
The following are the three consecutive steps that are performed in the process of analog to digital conversion

- ☐ Decoding, Quantization, Encoding
- ☐ Sampling, Encoding, Quantization
- ◉ Sampling, Quantization, Encoding
- ☐ Decoding, Quantization, Sampling

Q27
You are designing the electric power generation subsystem for a satellite in a 1000 km circular Earth orbit. Average power needed during eclipse conditions is 350 W and during sunlit conditions 700 W. You have selected a photovoltaic system with a path efficiency in daylight of 85% and during eclipse of 65%. Determine for this satellite the power to be provided (in kiloWatt) by the solar array.
1.0916

Q28
Which of the following functions generally are accomplished by the electric power subsystem.

- [ ] Provide propulsive power.
- [x] Provide ability to fire ordnance (explosive bolts, etc.).
- [x] Communicate health and status of the electric power subsystem to ground.
- [x] Protect the spacecraft against transient bus voltages.
- [ ] Command the rocket thrusters on/off.
- [ ] Control the temperature of the electric power subsystem

Q29
When using Time Domain Multiple Access (TDMA), the different users are spread out over the frequency domain.

- ( ) True
- (•) False

Q30
Indicate the percentage DOD allowed for a NiCd battery in case the battery goes through 10,000 charge-discharge cycles.

- ( ) 60-70 %
- ( ) 50-60 %
- (•) 30-40 %
- ( ) 10-20 %

Space Quiz 1

Q1

A plate with dimensions 3.5 x 10 cm is in deep space. The plate has a 2 mil Aluminized Teflon coating. The temperature of the plate is 114 degrees Centigrade.
How much heat will the aforementioned plate radiate?
Give the answer in Joules.
5.876

Q2

When is the gravity gradient torque the lowest for a satellite with principle moments of inertia along the body axes of , ,
If the satellite body z-axis is pointing exactly to the centre of the earth
[Given; If the satellite body x-axis is pointing exactly to the centre of the earth
If the satellite body y-axis is pointing exactly to the centre of the earth
The gravity gradient is equal for all three cases above]

Q3

Due to the earth's orbit being elliptical, the intensity of the sunlight reaching earth varies by approximately:
3.5%
[Given; 10% , 1% , 5%]

Q4

The disadvantages of Gravity-gradient control method is that it is limited to 1 or 2 possible orientations
True

Q5

The sequence of subsequent rotations around the Euler axes influences the final rotation matrix
True

Q6

What is de definition of a Launch Vehicle (L/V) Dynamic Envelope?
The total volume under the fairing exclusive a certain margin to account for spacecraft vibrations
[Given; The total volume under the L/V fairing , Neither 1) or 2)]

Q7

Quasi-Static Loads (QSL) may be applied when the spacecraft (S/C) lowest natural frequency is the specified natural frequency
False

Q8

A single-spin satellite, with some internal energy dissipation but no external disturbance torques is stable if the rotation axis coincides with:
The direction of the largest moment of inertia

[Given; The direction of the smallest moment of inertia, The direction of the intermediate moment of inertia]

Q9

Precession is the torque-free motion of the spacecraft body when the angular momentum vector is not perfeclty aligned along a principle axis of inertia
True

Q10

- Aerodynamic (LOE)
- Magnetic
- Gravity gradient
- Solar radiation (independent)

A. Independent
B.
C.
D.

Q 11
Cell Dimpling means
Failure mode in the facesheet of a sandwich structure
[Given; Failure mode in a stringer , Failure mode in the honeycomb core]

Q12
In mechanics the slew rate is given in dimension 1/T and is associated with the change in position over time of an object which orbits around the observer.
True

Q13
MAC means Modal Assurance Criterion as well as Mass Acceleration Curve
True

Q14
What is the attitude control of a SC?
Control of the angular position and rotation of the spacecraft
[Given; Control of the azimuth of a spacecraft , Control of the elevation of a spacecraft , Control of the rotation about the x-axis of a spacecraft]

Q15
What type of control law is

- [ ] P-Control
- [x] PD-Control
- [ ] PID-Control
- [ ] Adaptive control

Q16
What is the most important source of disturbance torques for GEO satellites?
Solar radiation
[Given; Gravity gradient, Magnetic field , Aerodynamic friction]

Q17
Passive Control; Rely on dynamics of the spacecraft or characteristics of disturbance torques to control attitude
Active Control; Torque capabilities are created to command desired attitude and counteract the effects of disturbances

Q18
The terms 'set point' and 'dead band' apply to which component present in a Spacecraft?
Thermostat
[Given; Heater, Radiator, Battery]

Q19

A Scientific Instrument demands an experiment, enveloped in a sphere. The sphere should have the highest possible temperature, without active heating.
The sphere is only illuminated by the sun and radiates to space.
What is the ranking of the coatings to create high temperatures?
Order from best to worst
The a/e ratio represents the alpha/epsilon ratio

3 Black (a/e = 0.9/0.85) = 1.05
5 Optical Solar reflectors (0.1/0.8)=0.125
2 Aluminum (a/e = 0.15/0.05) = 3
1 Gold (a/e = 0.25/0.03) =8.333
4 White (a/e = 0.2/0.85) = 0.235

Q20
What type of control law is: ?

- P-Control
- PD-Control
- PID-Control
- Adaptive control

Q21
A dual-spin satellite, with energy dissipation devices on the de-spun platform is stable if the rotation axis coincides with (Multiple answers possible):
The direction of the smallest moment of inertia.
The direction of the largest moment of inertia.
[Given; The direction of the intermediate moment of inertia, None of the above]

Q22
Thermal Control would be impossible if Spacecraft were black bodies, except perhaps by varying the internal heat dissipation
True

Q23
For which one of the following may Albedo be neglected?
GEO
[Given; High Earth Orbits, LEO]

Q24
What means SRS?
Shock Response Spectrum
[Given; Special Resource System, Sum Root Squares]

Q25
What is the definition of Margin Of Safety? (MS)
Allowable load divided by the design loads minus one.
[Given; Equal to the reserve factor, Equal to safety factor.]

Q26
In failure mode, Equipment dissipation is;
0

Q27
If you know that the solar constant in Earth Orbit is 1371 W/m^2 and that the planet Mercury has a distance to the sun of 0.4 AU. The Solar intensity in an orbit around Mercury is …
(1/0.4^2) * 1371..... 8569 W/M^2
[Given; 5484 W/M^2 , 3427 W/M^2 , 548]

Q28
One variable speed double-gimbaled control moment gyro can deliver control torques around all three body axes
False

Space Quiz 2
19.5 out of 29.5 points

Q1
The following are the three consecutive steps that are performed in the process of analog to digital conversion

- [ ] Decoding, Quantization, Encoding
- [ ] Decoding, Quantization, Encoding
- [x] Sampling, Quantization, Encoding
- [ ] Decoding, Quantization, Sampling

Q2
You are designing the electric power generation subsystem for a deep space probe. For this probe you have decided you will use RTGs. For most of the time the power needed by the probe is 400W, except that every hour the probe will be in contact with Earth for about 10 minutes (min.). During these contacts the power needed is 1000Watt (W). As RTGs are designed for average output and not peak, the additional power is obtained from a storage device. For a path efficiency of 80% during normal conditions and 60% when drawing power from the storage device, you are asked to determine the average power to be provided (in Watt) by the RTGs.
750

Q3
Consider the following ground station receiver chain;
Antenna - coaxial cable A- Low Noise Amplifier - coaxial cable B - Receiver
The Low Noise Amplifier is placed as close to the antenna as possible in order to:

- [x] Reduce the influence of coaxial cable A
- [ ] Reduce the influence of coaxial cable B
- [ ] Increase the antenna gain
- [ ] Increase the system noise temperature

Q4
Indicate the percentage DOD allowed for a NiCd battery in case the battery goes through 10,000 charge-discharge cycles.

- [ ] 60-70 %
- [ ] 50-60 %
- [x] 30-40 %
- [ ] 10-20 %

Q5
One wants the minimum quantization error to be less than 0.5%. What is the minimum number of bits per sample, including parity, which one would have to use? (Parity is 1bit)
8

Q6
Consider a communications link that has a Bit Error Rate of 5*10^-4. How many bits out of 10,000 bits will be corrupted?
5

Q7
You are designing the power subsystem of an Earth Observation satellite in Low Earth Orbit (LEO) with an orbital period of 100 minutes (min). The power required by the payloads on board of this satellite is:
- 100W during 80min.
- 50W during 40min.
- 1000W during 10min.
Determine the average power needed per orbit assuming that the spacecraft (S/C) subsystems add 25% to the power used by the payloads.

- ☐ 1150 W
- ☐ 1437.5 W
- ◉ 250 W
- ☐ 143.75 W

Q8
If one uses BPSK R-1/2, K=7 Viterbi Soft DEC with a Eb/No(Energy per bit divided by the noise spectral density), what is the probability of Bit Error?

- ☐ 10^-4
- ☐ 10^-5
- ◉ 10^-6
- ☐ 10^-7

Q9
We need to calculate the minimum data rate to transfer Voice PCM (Reader A1 pager 175). We want the maximum quantization error to be 0.1%. We will also add 1 parity bit. Give the data rate in kbps.
80

Q10
You have designed an EPS with an array regulator, battery charge & discharge regulator. The efficiencies of the system are:
- Array regulator: 90%
- Electric wiring to the battery: 99%
- Battery charge regulator: 90%
- Battery: 90%
- Battery discharge regulator: 95%
- Electric wiring from battery to the loads: 97%
Calculate the efficiency (as percentage of power generated at the array) of the path from the solar array through the battery to the loads.
66.5

Q11
Given information about a circular antenna:
-The carrier frequency is 2GHz.
-The antenna diameter is 2m.

What is the half-power beamwidth? Give the answer in degrees.
5.25 (pg 555 SMAD)

Q12
We have a high quality parabolic ground antenna. The radius of the aperature is 1 cm. What is the effective receive antenna aperature area Ar. The efficiency is 0.7.
Give the answer in [cm^2]
2.2 (pg 423 SSE)

Q13
Calculate the required datarate for a voltage measurement on board a spacecraft which requires an accuracy of 0.1V and has to be performed over a range of 0-5V, with a measurement frequency of 10Hz. (One parity bit included)
132

Q14
You are considering the use of a fuel cell to produce the power for a Mars buggy. This buggy uses 200W of electrical power. Operational life of this buggy is 2 weeks. Determine the amount of reactant (in kg) that must be carried on board of this buggy in case the fuel cell has a reactant consumption of 0.5 kg/kwh.
33.6

Q15
When using Time Domain Multiple Access (TDMA), the different users are spread out over the frequency domain.
False

Q16
You are designing the electric power generation subsystem for a satellite in a 1000 km circular Earth orbit. Average power needed during eclipse conditions is 350 W and during sunlit conditions 700 W. You have selected a photovoltaic system with a path efficiency in daylight of 85% and during eclipse of 65%. Determine for this satellite the power to be provided (in kiloWatt) by the solar array
1.139
现在答案：*((105.12-34.94)*700/0.85+34.94*350/(0.65))/(105.12-34.94)=1.0916*
原答案：*((105.12-34.94)*700/0.85+34.94*350/(0.65**0.85))/(105.12-34.94)=1.1389*
换题：*350W->550W*
1244.8

Q17
A frame of 200 bits is being transmitted. If the BER is 2 * 10^-4, what is the probability that the frame arrives with no errors?
0.96

Q18
Of the following functions, list the ones that are performed by the C&DH system (pg 452 SEE)

- [x] On-board time keeping
- [x] Command processing
- [ ] Temperature control
- [x] Telemetry frame generation
- [x] station keeping

Q19 Page 128 of reader
You are designing a planar solar array. You have calculated that the array must provide 1000 Watt of electrical power End Of Life (EOL). For a solar illumination intensity of 1367 W/m^2, a cell efficiency of 15%, an inherent degradation of 0.75 and a solar cell degradation of 2% per year, calculate the size (in meters squared) of the solar array for an average Sun incidence angle of 10 degrees and a 5 year operational life. (pg 128 of reader)

- (•) 7.3 m^2
- ( ) 0.65 m^2
- ( ) 6.5 m^2
- ( ) 6.6 m^2

Q20
Which of the following characteristics can be considered as an advantage of an external energy source over an internal one?

- [x] The mass of the power source does not have to be taken into account.
- [ ] The power delivered varies with the distance.
- [ ] The total amount of energy needed does not influence the design of the power system.

Q21
Which of the following statements are true:
1. Battery capacity changes with discharge rate (i.e. current being drawn from the battery)
2. Lower battery temperature significantly reduces battery capacity
3. How much current a battery delivers is independent of the load resistance
4. The older a battery becomes, the lower will be the capcaity that can be obtained from it
5. A possible unit for battery capacity is Ampere/kg

- (•) 1,2,4
- ( ) 1,3,4
- ( ) 2,3,4
- ( ) 1,4,5

Q22
Convert 20,000 to dB
43

Q23
Pick the functions which a CD&H system carries out

- [x] Time keeping
- [x] Computer Watchdog
- [ ] Attitude Control
- [ ] Propulsion
- [ ] None of the above

Q24
What is the minimum required
in order to obtain a Bit Error Rate of when using FSK modulation?
12

Q25 (pg 416 SMAD)
The solar array area needed to produce a certain amount of power depends on the lay-out of the solar cells on the vehicle. We distinguish wing-mounted and body-mounted cells. Which of the ratios indicated below gives best the solar cell area ratio between:
- wing-mounted cells (with full tracking of the Sun): A_wing
- body mounted cells on a cylindrical spinning satellite (spin axis perpendicular to the Suns' rays): A_spin, and
- body mounted cells on a free tumbling cubic satellite; A_cube.
Note: Pi = 3.14...

- [ ] A_wing : A_spin : A_cube = 1 : Pi : 2
- [ ] A_wing : A_spin : A_cube = 1 : Pi : 6
- [ ] A_wing : A_spin : A_cube = 1 : 2Pi : 6
- [x] A_wing : A_spin : A_cube = 1: Pi : 4

Q26
You are designing an RTG for an electric power output of 500W. The thermal to electric conversion efficiency is 8%. Determine for this RTG how much thermal power (in Watt) is to be removed to keep the temperature of the RTG stable.
460
500/0.08-500=5750
*500/0.06-500=**7833.33***

Q27
At the subsystem level, the TT&C subsystem interfaces directly with every subsystem except for ....

- [x] Propulsion
- [ ] Power Supply
- [ ] Thermal Control
- [ ] Attitude determination and control

Q28
Which of the following functions generally are accomplished by the electric power subsystem.

- [ ] Provide propulsive power.
- [x] Provide ability to fire ordnance.
- [x] Communicate healt and status of the electric power subsystem to ground.
- [x] Protect the spacecraft against transient bus voltages.
- [ ] Command the rocket thrusters on/off.
- [ ] Control the temperature of the electric power subsystem

(pg 407 SMAD)

Q29
You are designing a satellite to ground link for television broadcast operating at 20GHz. The link requires an availability of 99.5% for users that view the satellite at 10 degrees antenna elevation. What is the rain attenuation in dB that you should take into account in your link budget?
4 (pg 565 SMAD)

Space Quiz 3 26.1/31.1

Question 1:
For the next few observations, select the best waveband.
C (VIS) - Daylight conditions, passive instrument, high ground resolution.
D (Microwave) - Night time observations during bad weather, passive instrument.
A (Radar) - Night time observations, during bad weather, good contrast.
B (IR) - Night-time observations, clear sky.
Page 84 of the reader.

Question 2:
For your spacecraft you have a single ground station available. For data transfer, it is required that this station is always in view of the spacecraft. What orbit would you choose for this spacecraft: GEO, geosynchronous or LEO orbit?
Both GEO and geosynchronous will do.
Page 121 of SMAD.

Question 3:
What is the peak wavelength (wavelength of maximum emission) of boiling water at a temperature of 100 degrees Celsius give the answer in micro meters.
First you need to convert from Celsius to Kelvin: T=100+273.15=373.15 K. Now use Wien's law (page 80 of the reader): lambda=2900/373.15=7.77167359 micro meter.

Question 4:
You aim to provide images with a ground resolution of 1m. You are considering the use of a LEO satellite in an 800 km circular orbit. What is the required angular resolution (in arcsec) for you instrument?
X=theta*h (page 86 of the reader, ignore the 2 in the formula because that's wrong). Theta=1.25E-6 rad. Now convert to arcsec (page 920 of SMAD): 1.25E-6*(648,000/pi) =0.2578310078 arcsec.

Question 5:
At lift-off, the Ariane 5 space launcher is propelled by two solid rocket boosters, each delivering 6.7MN of thrust for 130 sec. The exhaust gases producing this thrust leave the engine with an effective velocity of 2650 m/s. Determine the total propellant mass in kg expelled during the operation of the two boosters.
Calculate the mass flow (page 62 of reader A2): m=F/w=6.7*10^6/2650=2528 kg/s. So the total propellant mass expelled is: 2*130*2528=657,000 kg (first answer).

Question 6:
The the propulsion of the main cryogenic stage of Ariane 5, 25 tonnes of liquid hydrogen is stored in a cylincrical tank in the launcher. The diameter of the tank is 5.4m and the liquid hydrogen density is 70 gram/liter. How tall must the cylindrical tank be to contain this quantity of liquid hydrogen.
Not too difficult to calculate. Final answer: 15.6 m.

Question 7:
A satellite costs 100 million Euro, which has been paid for by a group of wealthy investors. Operations cost of the satellite are 10 million Euro per year. Earnings each year are 100 euro per user. How many users are needed (constant in time) to allow for paying back the investors in full after 10 years and to give them a profit of 10% ROI?
Answer: 300,000 users (mission concept exploration feedback test). 10 mln annual costs + 10 mln roi + 10 mln investment payback = 30 mln. 30*10^6/100=300,000 users.

Question 8:
You are designing a solar sail propelled vehicle. You are considering a square solar sail with sides of 1 km, an absorptivity of 0.15 on the front (opposed to the sun) and thermally insulated back. Solar constant is 1400 W/m^2. what is the maximum acceleration force that the sail produces on a vehicle 2.1 AU from the Assuming that the sail is in thermal equilibrium?
Calculate the solar flux at 2.1 AU: S=1400*(1/2.1)^2=317W (formula is on page 111 of reader A2). Use the formula on page 122: F=A*p=1000^2*(1400/2.998*10^8)*(2-1/3*0.15)=9.1 N. 9.1N

Question 9: (Not 100% sure)
You are asked to provide for a spectrometer with a spectral resolving power of 10^4 at 100 micro meters. What is the required spectral resolution of this instrument (in micro meters).
100/10^4=0.01; page 89 of reader.

Question 10:
The radiation that falls onto a sail causes the sail temperature to rise.
True.

Question 11:
Match the following parameters with the appropriate unit:
C - Spectral radiance
A - Radiant flux density → Should be W/m^2 and not W
B - Radiant intensity
D - Radiance
Pages 77, 78, 79 of reader.

Question 12:
What is the mass of 6000 km long tether made of aluminium (2.8 kg/liter) with a diameter of 2.5 mm?
Not too difficult: 82.5 tonnes (first answer).

Question 13:
The cryogenic main stage of the Arian 5 launcher produces a thrust of 1.15 MN. The average (over the altitude range) specific impulse is 420 sec. What is the jet power produced by this engine?
Calculate the exhaust velocity: w=g*I=10*420=4200. The jet power is: 0.5*1.15*10^6*4200=2.4 GigaWatt (first answer). Pages 56 and 57 of reader A2.

Question 14:
A typical spacecraft description includes:
Answer: 1,2,4, the last answer (feedback test on space mission concept exploration).

Question 15: (Not 100% sure)
Which methods can be used to limit the depth of analysis in any particular area?
1. To focus on the system drivers
2. to focus on the key requirements
3. To clearly identify the goal of the analysis and to provide a level of detail appropriate to that goal.
4. to use experienced designers.
I would go for the third answer: 1,2,3.

Question 16:
The moon's radius is 1738 km. The distance between an observer on Earth and the Moon is (on average) 384401 km. What is for the observer the solid angle of the Moon. Give the answer in steradians. You may assume that the frontal area of the Moon and the area of the spherical cap cut out by the Moon are identical.
Area moon: A=pi*1738^2=9489633 km^2
Surface of a sphere with radius of 384401 km: 4*pi*384401^2=1.9E12 km^2
Solid angle of a sphere is 4pi, so the solid angle of the moon is (approximately): (9489633/1.9E12)*4pi=6.4E-5

Question 17:
You have an aluminium ED tether of length 2 km, cross-sectional are of 4 mm^2 and a specific resistance of 27*10^-9 ohm-m. This tether is in a circular orbit about Earth at an altitude of 600 km and an inclination of 83 degrees. In case magnetic latitude is identical to the geocentric latitude, what is the maximum current in the tether?
R=(2000/4*10^-6)*27*10^-9=13.5
I = V/R=(2000*7558*(6378000^3*31*10^-6/6978000^3))/13.5=26.5A
Use the formula on page 130 of reader A2.

Question 18:
The system specific impulse of a rocket system with a separate energy source…
Reaches a maximum for a specific exhaust velocity. See pages 56 and 103 of reader A2.

Question 19:
A 1 N resistojet uses nitrogen as propellant. Specific heat ratio of the nitrogen is 1.4, molar mass is 28 gram/mole and nozzle pressure ratio is 10000. Determine the chamber temperature needed to achieve a true exhaust velocity of 2500 m/s.
Use the formula on page 63 of reader A2. Answer: 3240K

Question 20:
A scientist has asked to observe a planet with a temperature of 600K at a wavelength of 15 micro meters. Determine the spectral radiance in (…) of this planet at this wavelength.
See table on page 91 of the reader: 4.0E7.

Question 21:
A farmer would like to be informed about when to water his plants. From research you have learned that the percent reflectance of the plants under consideration in the green waveband (say 500-600 nanometre) changes with the moisture content of the plants form 10% when soaked to 30% when dry. What is the minimum amount of power (in W) reflected by a plant area of size 100m x 100m in case the atmospheric absorptance in this waveband is 80%? You may assume that the Sun radiates at a temperature of 6000K and that in total 1400 W/m^2 arrives at Earth.
Min: 100*100*1400*0.1*(1-0.8)=280000 W

Question 22:
Put the following requirements in the order of which they are derived in time.
2 - System requirements
4 - Equipment or unit requirements
3 - Subsystem requirements
1 - Mission requirements
Page 8 of the reader.

Question 23:
Thrust and specific impulse of a thermal rocket motor…
Decrease with decreasing altitude. See the graph on page 68 of reader A2.

Question 24: (Not 100% sure)
Typical requirements for a navigation mission concern:
1. Position accuracy (for both static and dynamic users)
2. Time to first fix
3. User cost
4. Quality of navigation signal
5. Availability of navigation signal
Answer: All 5 (last answer).

Question 25:
Typical space propulsion tasks include:
- changing the location of the orbit ascending node
- perigee kick maneuver
- attitude control
- unloading of reaction wheels
- propellant settling
So only electrical power generation is no task.
See page 43 of reader A2.

Question 26:
A spherical propellant tank of the Globalstar S/C has a volume of 104 litres and a mass of 6.4 kg. MEOP is 24.6 bar and tank safety factor is 2. What is the tank mass correction factor K in case the tank is made of titanium with a mass density of 4430 kg/m^3 and a strength of 900 Mpa?
140l=0.140m^3; r=(0.104/(4/3*pi))^-1/3=0.29m; D=2*r=0.58m; t=1/((900*10^6)/(24.6*10^5*2*0.58/4))=7.9E-4; K=6.4/(7.9E-4*4*pi*0.29^2*4430)=1.7. So K=1.7. Use the formulas on pages 104/105 of reader A2.

Question 27:
Bij deze vraag is de volgorde iets anders iedere keer, dus let op!!!
D - Transmission of digital music=> BER<10^-9
B - Analog video=> S/N>57dB
C - Digital voice=> BER<10^-4
A - Digital video=> BER<10^-10
Page 23 of the reader (space concept exploration).

Question 28:
Requirements qualitatively define what the system should do.
False; it is quantitatively according to the definition on page 15 of the reader.

Question 29:
You are considering an Earth observation mission. You have selected a highly inclined Low Earth Orbit. Which of the aspects given below are considered an advantage of LEO versus Medium high Earth Orbit (MEO).
Answer: 2,3,5.

Question 30:
For a thermal rocket engine an increase in chamber pressure leads to an increase in true(=ideal) exhaust velocity.
True; see formula on page 63 of reader A2.

Question 31:
What is the order of the following activities in the design process of a propulsion system?
2 - Establish requirements (if need be per maneuver)
1 - Determine maneuvers to be performed
3 - Generate options for propulsion system
5 - Compare options and make choice
4 - Analyze propulsion system options
6 - Evaluate choice, document and if need be iterate
See page 50 of reader A2.

Question 32:
Data delivery options include:
All 5 (first answer)…Look at pages 22-28 in SMAD. We checked it, and it's correct.

Spacetest 3

Q1

The system specific impulse of a rocket system with a separate energy source...
Reaches a maximum for a specific exhaust velocity
[Given; Increases with increasing exhaust velocity, decreases with increasing exhaust velocity, Varies with the energy source selected, Is independent from the exhaust velocity.]

Q2

You have an aluminium ED tether of length 2km, cross-sectional area of 4m^2 and a specific resistance of 27*10^(-9) Ohm-m. This tether is in a circular orbit about Earth at an altitude of 600km and an inclination of 83 degrees. In case magnetic latitude is identical to geometric latitude, what is the maximum current in the tether?
26.5A
[Given; 265000,26500, 2.65]

Q3

Which methods can be used to limit the depth of analysis in any particular area?
1. To focus on the system drivers
2. to focus on key requirements
3. to clearly identify the goal of the analysis and to provide a level of detail appropriate to that goal.
4. to use experienced designers
1,2,3,
[Given; 13, 1234, 134]

Q4

A 1N resistojet uses nitrogen as propellant. Specific heat ratio of nitrogen is 1.4 molar mass is 28grams/mole and nozzle pressure ratio is 10000. Determine the chamber temperature needed to achieve a true exhaust velocity of 2500m/s.
3240K (Use the formula provided in Reader A2 page 63)

Q5

For a space science mission to Mars, you aim to measure the temperature of the Mars atmosphere. Temperature range is from -100 [c] to 0[c]. It is intended that single measurement is made every second with a dynamic range of 1000 (i.e. a measurement accuracy of 0.1[c]). Calculate the raw (digital) data rate generated per orbit (in kbps) from the measurements in case the orbit period is 80 minutes and the maximum quantisation error shall not exceed 0.01%, Focus on the measurement data rate only without considering compression, headers etc.

Q6

Put the following requirements in the order of which they are derived in time.
2. System requirements
4. Equipment or unit requirements
3. Subsystem requirements
1. mission Requirements

Q7
In STP design a solar thermal propulsion system is designed that is able to provide a thrust of 0.05N. Under the same assumptions as used in the above to referred document, you are asked to calculate/determine the mass (in grams) of the solar concentrator in case we design the system for a thrust of 5mN and a specific impulse of 120s.
0.51

Q8
A spherical propellant tank of the Globestar S/C has a volume of 104l and a mass of 6.4kg MEOP is 24.6bar and tank safety factor is 2. What is the tank mass correction factor K.In case the tank is made of titanium with a mass density of 4430 kg/m^3 and a strength of 900*10^6N/m^2
K=1.7
[Given; 0.6, 1.25, 1.3]

Q9
For a thermal rocket engine an increase in chamber pressure leads to an increase in true exhaust velocity.
True.

Q10
A satellite costs 100 million Euros, which has been paid for by a group of wealthy investors. Operations cost of the satellite are 10 million Euro per year. Earnings each year are 100 Euro per user. How many users are needed (constant in time_ to allow for paying back the investors in full after 10 years and to give them a profit of 10% ROI?
You may neglect any effect of interest over the money earned
300,000 users
[Given; 3000000, 100000, 1000000]

Q11
Which of the frequency bands would you select to broadcast (downlink) video services with a bandwidth of 0.5GHz?
2.5-2.7 GHz (within S-band)
[Given; 5.925-6.425GHz (C-band), 14.3-14.8 GHz (Ku-band), 11.7-12.5GHz (Ku-band)]

Q12
For the propulsion of the main cryogenic stage of Ariane 5, 25 tonnes of liquid hydrogen are stored in a cylinder tank in the launcher. The diameter of the tank is 5.4 m and the liquid hydrogen density is 70 gram/litre. How tall (in m_ must the cylindrical tank be to contain this quantity of liquid hydrogen?
15.6
[Given; 3.9, 1.56, 4]

Q 13
The radiation that falls onto a sail causes the sail temperature to rise
True

Q14
Match the following transmissions with the appropriate quality standard.
C. Transmission of digital music
D. Analog Video
A/ Digital voice.
B Digital video
(A; BER<10^-4, B; BER <10^-10, C; BER 10^-9, D; S/N>57dB)

Q15
Thrust and specific impulse of a thermal rocket motor;
Decreases with decreasing altitude
[Given; Increase with decreasing altitude, increases (thrust) and decreases(Specific impulse) with decreasing altitude, Decreases (thrusT) and increase (specific impulse) with decreasing altitude, remain constant with increasing/decreasing altitude)

Q16
At lift -off the Ariane 5 space launcher is propelled by two solid rocker boosters, each delivering 6.7MN of thrust for 130s. The exhaust gasses producing this thrust leave the engine with an effective velocity of 2650m/s. Determine the total propellant mass (in kg) expelled during the operation of the two boosters.
657000
[Given; 329000,3224000,67000]

Q17
The cryogenic main stage of the Ariane 5 launcher produces a thrust of 1.15MegaNewton. The average (over the altitude range) specific impulse is 420 s. What is the jet power produced but his engine?
2.4 GigaWatt
[Given; 240MW, 0.5GW,50MW]

Q18
Typical requirements for a navigational mission concern;
1.position accuracy (for both static and dynamic users)
2. Time to first fix
3. user cost
4. quality of navigational signal
5. availability of navigational signal
1,2,3,4,5
[Given; 145,12,134,1345]

Q19
Typical space propulsion tasks include
Changing the location of the orbit ascending node
perigee kick manoeuvre
altitude control
unloading of reaction wheels
propellant settling
[NOT electrical power generation!]

Q20
A typical spacecraft description includes
1. Mass
2. Reliability
3. User equipment cost
4. Up/downlink data rate
5. Mission life
6. Orbit
1,2,4
[Given; 146,123456,12456]

Q21
For your spacecraft you have single ground station available. For data transfer, it is required that this station is always in view of the spacecraft. What orbit would you choose for this spacecraft? GEO, geosynchronous or LEO?
Both Geo and Geosynchronous
[Given; GEO, LEO, No difference in LEO and GEO orbits in this case]

Q22
A group of scientist would like to view the night sky over a period of 1 year. During this period they would like to view the night sky 4 times. To obtain a shard picture, they aim to produce 1 frame every 12 hours. What is the minimum camera FOV solid angle allowed? See for definition of solid angle in the lecture notes, part B page 22.
0.069

Q23
What is the order of the following activities in the design process of a propulsion system?
2. Establish requirements (if need be per manoeuvre)
1. Determine manoeuvres to be performed
3. Generation options for propulsion system
5. Compare options and make choice
4. Analyse propulsion system options.
6. Evaluate choice, document and if need be iterate.

Question 24
You are designing a solar sail propelled vehicle. You are considering a square solar sail with sides of 1km, an absorptivity of 0.15 on the front (opposed to the sun) and thermally insulated back. Solar constant is 1400 W/m^2. What is the maximum acceleration force that the sail produces at 2.1 AU from the sun assuming that the sail is in thermal equilibrium.
9.1Newton
[Given; 9.1microNewton, 0.91 millinewton, 9.3 Newton]

Q25 Requirements qualitatively define what the system should do.
False

Q26
You are designing a search and rescue (S&R) mission. Market analysis has indicated 100,000 potential users as a service charge of 100/Euro/year/user. In case the system is paid for by the service charge (What is the maximum cost in million Euro) for the system to be designed (You may forget about inflation interest ROI) in case you aim for a design life of 7 years.
70

Q27
Data delivery options include
1. Direct to home or Via distribution centre
2. continuos or intermittent
3. Central control office handles user require
4. Extensive or in extensive data processing
5. mobile or fixed link
1,2,3,4,5
[Given; 2345,1235, 1245]

Q28
What is the mass of a 6000km long tether made of aluminium (mass density of 2.8kg/litre) with a diameter of 2.5mm?
82.5 tonnes
[given; 8.25 tonnes, 3300kg, 320 tonnes]

Q29
You are considering an Earth observation mission. You have selected a highly incline low earth orbit. Which of the aspects given below are considered an advantage of LEO versus medium high earth orbits (MEO)?
1. Wide area of view
2. High ground resolution
3. Limited amount of power needed for communication
4. high orbital velocity
5. low launch volt
2,3,5
[Given;1235,245, 125]

Space 4 20.1/28

Q1
You have estimated the development costs of some item at 50M$. You are considering spreading this cost over a period of 3 years. You decide to aim for 50% expenditure at some point midway. How much money (in M$) will you have spend after 12 months?
16.667

Q2
You are developing a platform for a space-based communication satellite. You aim to earn 100 million dollar per year. Which of the 4 S/C subsystems given below do you consider to be the highest risk item for the total system? See data contained in the lecture notes.
Altitude control subsystem
[Given; thermal subsystem, Reaction control subsystem (RCS), Electrical power subsystem (EPS), Altitude control subsystem (ACS)]

Q3
An unmanned space probe sent out to explore the solar system has an onboard computer with reliability characterised by the exponential distribution with a Mean Time To Failure (MTTF) of 1/ lambda = 30 months (A constant failure rate of 1/30=0.033 fails per month) The probability of surviving a two year mission is only e^(-24/30)=45. If, however, a second computer (in operating mode) is included in the probe which is consulted if the until then active computer fails, what will then be the reliability of this system?
0.6975
[Given; .2025, 0.2475, 0.7975]

Q4
Indicate the parameters of importance to illustrate how well the logistics is performed.
Availability
Maintainability
[Given; Mean repair time, cost of maintenance, Mean down time, mean time between failure.]

Q5
Given are 4 spacecraft with their respective masses and volumes;
Space craft 1. 45kg and 1m^3
“ “ “ “2. 100kg and 2m^3
“ “ “ “3. 150kg and 2.5m^3
“ “ “ “ “4. 200kg and 3 m^3
what is the average density for these four spacecraft? Give the answer in kg/m^3
55.416

Q6
You are asked to determine the largest contribution to the MMOI of a spacecraft (linear dimension 3m) Of a solar panel of size 40m^2 based on the table 10-30. You may assume a panel mass of 2.5 kg/m^2
4863 kg-m^2
[Given; 243, 2432, 215.4]

Q7
Failure mode is the reason that a certain item fails
False

Q8
You have estimated a dry spacecraft mass of 1000kg and a total electrical power of 3000W. S/C mass density of 100kg/m^3. Launcher available diameter is 3m. To provide for electrical power you have decided for an 3-axis stabilised vehicle equipped with two solar array wings (one on each side of the S/C) of identical size and with the array panel height identical to the S/C height. Determine the length of a single such wing.
12.7m
[Given: 13, 6.5, 3.9]

Q9
You are in charge of designing a S/C. For this S/C you distinguish 8 different subsystems. Your engineers have reduced a most likely estimate for the mass of these subsystems. THey also have computed a standard error for estimates. For the systems 1-4 this is 5% of the subsystems mass and for the systems 5-8 is 10%. What is the standard error (in%) of the sum of the subsystem Masses? You may assume that the individual estimates are independent from each other.
(60/8)%
[Given; 60% 22.36%, cannot be answered without further information]

Q10
You have designed a power distribution and control subsystem for the international space station (ISS). This system has a reliability of 90% over a 1 year life time. By keeping the system modular and by having repair items in inventory on board of ISS, you are able to limit average down time to 2 weeks. Determine the availability of this system for ISS
99.596
[Given; 99.615, 90, 0.385]

Q11
You have designed a system with a reliability of 0.8 over 10 years. What is for this system the failure or hazard rate in case you assume a constant failure rate over the operational life of the system.
0.0223 failures per year
[Given; 0.2, 0.02, 20%]

Q12
Consider the bus as described in the problem 10.7 from the problem book. USing the data from the probled description, you are asked to determine the total power that should be generated by the electrical power generation subsystem of the bus.
110

Q13
What budgets shall be determined/controlled by the S/C engineer?
Propellant budget
Mass budget
reliability
[Given; Mission Delta-v budget, volume, cost]

Q14
You are designing the AOCS system or a large spacecraft. This system has two sensors. Sensor S1 has a failure rate of 0.1 failure per year and sensor S2 has a failure rate of 0.01 failure per month. Determine the failure probability of this system over a 2 year life time.
0.36
[Given; 0.22, 0.44, 0.88]

Q15
You have decided for a S/C with a rectangular box-shaped body. This body is of size 2.6x2.8x2.5m. The mass of this body is homogeneously distributed with a mass density of 100 kg/m^3. Determine for this body the maximum mass moment of inertia (MMOI) about the body axes in case we are dealing with an orthogonal centroidal axes system.
2214 kg-m^2
[Given; 1820, 1420, 2713]

Q16
You are in charge of designing a S/C. For this S/C you have estimated a mass of 4000kg. Of these you have distributed 3200kg over the 6 subsystems (20% is kept in reserve). Your engineers have estimated subsystem mass as well s the standard error of the estimate. For each of the subsystems 1-3 this is 6% of the vehicles mass of4000kg. For each of the subsystems 4-6 this is 18% of the vehicle mass. Total subsystem mass estimated is 3198kg. What is the standard error (in%) of the sum of the subsystem masses? You may assume that the individual estimates are independent from each other.
41.2%
[Given; no answer possible, 32.9, 12]

Q17
Match the following vehicle types with the (GTO) capacities;
C HLLV
A LLV
B MLV
D SLV
(A;2000-5000, B; 1000-2000, C>5000, D<1000)

Q18
You have tested 4 items during 3 months of operation. During this time, you have logged 1 failure occurring after 1 month of operation, which has been immediately repaired (negligible repair time). You continue testing these 4 items during 9 more months with 1 failure occurring after 6 months and 1 after 7 months. Both were repaired with again negligible repair time. Determine for this item the probability that a single test item will survive a test time of 1 year.
0.472
[Given; 0.75, 25%, 99%]

Q19
There are 4 individual independent estimates for the costs of 4 different components. The summation gives the total cost. Five the standard error of the sum if the individual errors are; $1000, $100,000, $5000 and $75,000.
24934.5
Q20
The Hubble Space Telescope (HST) contains 4 gyroscopes with a MTBM of 2 years. After each two-year period all gyroscopes are replaced by a replacement unit. This takes about 3 months of preparing for launch including the launch itself, two weeks for installation and alignment and 2 weeks to determine long and short time drift for all four gyroscopes. During this period, no observations are possible. Determine the availability of the HST for observations based on the maintenance of the gyroscopes only.
96.3%
[Given; 0.037, 0.996, 0.867]

Q21
You have on board 20 active transponders. For the system to be successful at least 16 of these transponders need to remain active over the full mission life of 10 year. In case the reliability of a single transponder is 0.95 over the 10-year life, what is the probability that at least 16 transponders will survive.
99.7%
[Given; 0.95^16=0.44, 0.05^4=0.000625%, 1-0.95^16*0.05*4=99.99962%]

Q22
You are designing a small earth orbiting satellite with a dry mass of 50kg. Using SMAD, you are asked to determine for this S/C the S/C cost (in FY00 M$).
4.403777675

Q23
Risk is the potential for realisation of unwanted, adverse consequences to human life, health property or the environment.
True

Q24
Determine the availability of a system with; Stand down time =1.0, Surge= 1.4, L=8 and reliability=1.0
1

Q25
You are to produce 100 processing chips. The theoretical first unit cost (TFU) is $200. What is the total production cost if the learning curve slope is 95%? Give the answer in dollars.
14224.23

Q26
A FITS of 1 for a computer means that this computer typically will experience 1 failure every billion hours.
True

Q27
A satellite mission costs 500 million dollars. The money will be paid back after a period of 3 years including an interest rate of 6% a year. What is the cost of financing? (Give the answer in M$)
96

Q28
Injected weight is the mission capable spacecraft weight
True.

Q29
See the problem 11.1 from the AE2-S02 workbook “problems”. Determine the availability (expressed as a percentage) of the launcher with highest availability
96

Test 2 24.5/30.75

Q1

For the receiving ground station you have selected a circular antenna with a gain of 50dBi. Determine for this antenna the half power beam width (in degrees)

0.515

Q2

Which of the following characteristics can be considered as an advantage of an external energy source over an internal one?

The mass of the power source does not have to be taken into account.

[Given; the power delivered varies with the distance, the total amount of energy needed does not influence the design of the power system]

Q3

Which of the following statements are true?

1. Battery capacity changes with discharge rate (I.e. current being drawn from the battery)
2. Lower battery temperature significantly reduces battery capacity
3. How much current a battery delivers is independent of the load resistance
4. The older a battery becomes, the lower the capacity that can be obtained from it
5. a possible unit for battery capacity is Ampere/kg

124

[Given; 134, 234, 145]

Q4

One wants the minimum quantisation error to be less than 0.15%. What is the minimum number of bits per sample, including 1 parity bit, which one would have to use? A parity bit is a bit that is added to ensure that the number of bits with the value one in a set of bits is even or odd. Parity bits are used as the simplest form of error detecting code.

10

Q5

The on board data storage system (part of the C&DH system) of a LEO S/C is capable of storing 1 GByte. Given a ground contact time of 10 minutes, you are asked to calculate the required data transmission speed (in Mbps, accurate up to 2 digits behind the decimal point) required when in contact with ground to empty the storage system completely.

13.33

Q6

You are designing the electric power generation subsystem for a satellite in a 1000km circular Earth orbit. Average power needed during eclipse conditions is 550W and during sunlit conditions 700W. You have selected a photovoltaic system with a path efficiency in daylight of 85% and during eclipse of 65%. Determine for this satellite the power to be provided (in Watt; accurate up to 1 digit behind the decimal sign) by the solar array. Duration of eclipse and daylight may be obtained from SMAD (table back cover)

1244.8

Q7
Which of the following functions generally are accomplished by the electric power subsystem.
provided ability to fire ordnance (explosive bolts etc)
Protect the spacecraft against transient bus voltages.
[Given; Provided propulsive power, Communicate health and status of the electric power subsystem to ground, Command the rocker thrusters on/off, Control the temperature of the electrical power subsystem]

Q8
Consider the following ground station receiver chain;
Antenna- Coaxial cable A- Low noise amplifier- coaxial cable B- receiver
reduce the influence of coaxial cable A
[Given; reduce the influence of coaxial cable B, increase the antenna gain, increase they system noise temperature]

Q9
You are designing a satellite to ground link for television broadcast operating at 20GHz. The link requires an availability of 99.% for users that view the satellite at 10 degrees antenna elevation. What is the rain attenuation in dB that you should take into account in your link budget?
9

Q10
For a mars spacecraft communicating with EArth we need a really large antenna to make sure that the signal can be detected and read. Suppose that our S/C is communicating in a frequency band with lowest frequency of 2GHz and that we are considering the use of a circular antenna with an diameter of 5m and an efficiency 0.7. What is for this antenna the peak gain (in dBi) that can be achieved as compared to an isotropically radiating antenna?
38.86098

Q11
If one uses BPSK R-1/2. K=7 Viterbi Soft DEC with an Energy per bi to noise spectral density ratio (Eb/No) equal to 5dB, what is the Bit Error rate?
10^-6
[Given; 10^-5, 10^-7, 10^-8] (fig 13-9 in SMAD)

Q12
You have designed an EPS with an array regulator, battery charge and discharge regulator. The efficiencies of the systems are;
Array regulator 90%
Electrical wiring to the battery 99%
Battery charge regulator 90%
Battery 90%
Battery discharge regulator 95%
electric wiring from battery to the loads; 97%
Calculate the efficiency (as percentage of power generated at the array) of the path from the solar array through the battery to the loads.
66.5

Q13
You are designing the electric power generation subsystem for a deep space probe. For this probe you have decided to use RTG's. For most of the time the power needed by the probe is 800W, except that every hour the probe will be in contact with the earth for about 10 min. During these contacts the power needed is 1000W. As RTG's are designed for average output and not peak, the additional power of 200W is obtained fro a storage device. FOr a path efficiency of 80% during normal conditions and 60% when drawing power from the storage device, you are asked to determine the average power to be provided (in Watt; accurate up to 1 digit behind the decimal point) by the RTG's
1055.56

Q14
We need to calculate the minimum data rate to transfer voice PCM (A1 page 175). We want the maximum quantization error to be 0.1%. We will also add 1 parity bit. Give the data rate in kbps
80

Q15
You are considering the use of a fuel cell to produce the power for a Mars buggy. This buggy uses 200W of electrical power. Operational life of this buggy is 2 weeks. Determine the amount of the reactant (in kg) that must be carried on board if this buggy in case the fuel cell has a reactant consumptions of 0.5kg/kwh.
33.6

Q16
You are designing an RTG for an electric power output of 500W. The thermal to electric conversion efficiency is 6%. Determine for this RTG how much thermal power (In Watt) is to be removed to keep the temperature of the RTG stable.
7833.33

Q17
You are designing a planar solar array. You have calculated that the array must provide 1000 Watt of electrical power End Of Life (EOL). For a solar illumination intensity of 1367 W/m^2, a cell efficiency of 15%, an inherent degradation 0f 0.75 and a solar cell degradation of 2% per year, calculate the size (in meters squared) of the solar array for an average SUn incidence angle of 10 degrees and a 5 year operational life.
7.3 m^2
[Given; 0.65, 6.5, 6.6]

Q18
Indicate the percentage DOD allowed for a NiCd-battery in case the battery goes through 10,000 charge-discharge cycles
30-40
[Given; 60-70,50-60,10-20]

Q19
A frame of 200 bits is being transmitted. If the BER is 2*10^-4, what is the probability that the frame arrives with no errors?
0.96078

Q20
The solar array area needed to produce a certain amount of power depends on the lay-out of the solar cells on the vehicle. We distinguish wing-mounted and body-mounted cells Which of the ratios indicate below gives the best solar cell ratio between;
-Wing mounted cells (with full tracking of the Sun): A_wing
-body mounted cells on a cylindrical spinning satellite (spin axis perpendicular to the Suns' rays): A_spin, and
-body mounted cells on a free tumbling cubic satellite; A_cube.
note p=3.14
A_wing: A_spin: A_cube=1:p:4

[Given; A_wing: A_spin: A_cube=1: p:2
A_wing: A_spin: A_cube=1:2p:4
A_wing: A_spin: A_cube=1:p:6]

Q22
Of the following functions, list the ones that are performed by the C&DH system
On-board time keeping
Command
Telemetry frame generation
[Given; Temperature control, station keeping]

Q23
What is the minimum required Eb/No in order to obtain a Bit Error Rate of 10^-5 when using BPSK modulation?
9.6

Q24
When using Time Domain Multiple Access (TDMA), the different users are spread out over the frequency domain.
False

Q25
You are designing the communications link of a spacecraft in orbit about Mars with a ground station on Earth. Transmitter power is 100W. Distance from Mars to Earth is in the most critical case 100million km. Given that the transmitter is perfect, no losses, that the power is radiated equally in all directions and that losses due to antenna pointing and or propagation and polarisation can be neglected, you are asked to calculate the power flux density received on earth. Give the answer in 'yocto-Watts per meter squared' (yocto=10^-24).
795.77

Q26
The following are the three consecutive steps that are performed in the process of analog to digital conversion
Sampling, Quantisation, Encoding
[Given, Decoding quantisation encoding, sampling encoding quantisation, decoding quantisation sampling]

Q27
For housekeeping purposes various temperature signals are measured on board of our S/C. Since S/C spins about its longitudinal axis, it is expected that the temperature signals will vary with the rotational rate. Given a rotational rate of 120 rounds per minute (Rpm), that we measure 50 temperature signals with each signal producing a voltage output in the range of 5-10mV, that we need a measurement accuracy 0.1mV (no parity bit added), you are asked to calculate the minimum required data rate (in bits per second,bps) needed to be able to reproduce the actual signal.
1100

Q28
You are designing the power subsystem of an earth observation satellite in LEO with an orbital period 100 min. The power required by the payloads on board of this satellite is;
-50W during 80min
-100W during 40min
-2000W during 10min.
Determine the average power needed in orbit assuming that the spacecraft S/C subsystems add 25% to the power used by the payloads.
350W
[Given; 2150, 280, 250]

Q29
You have selected wire with gauge number 16 as the size of the electric wiring to provide 150Watt of electric power to one of the payloads on board of your spacecraft. Bus voltage is 50V. Wire length is 50m. Determine the percentage of power loss in the wire
4

Q30
We are designing the C&DH system of a spacecraft producing 1kbps of science data (throughout the day). For housekeeping 500 parameters are measured at a rate of 1Hz and 12 bits accuracy + another 50 at a rate of 10Hz and 16 bits accuracy. In case this S/C on average has 3 times a day contact with the ground station for a period of 10minutes you are asked to calculated the on board capacity (in GBtye) in case the contact times are evenly distributed that time the storage empties completely.
0.054

Bonus test 3

Q1

Effective exhaust velocity and true velocity are one and the same for a chemical rocket engine.
False

Q2

For the propulsion of the main cryogenic stage of Ariane 5, 25 tonnes of liquid hydrogen are stored in a cylindrical tank in the launcher. The diameter of the tank isn 5.4m and the liquid hydrogen density is 70g/litre. How tall (in m) must the cylindrical tank be (assume flat end caps) to contain this quantity of liquid hydrogen
15.6?
[Given; 3.9, 1.56, 4]

Q3

A 3 axis stabilised cubical S/C with principal MMOI of 1000kg-m^2 (about each of these vehicle axis) experiences a disturbance torque of 0.1Nm. Assuming worst case conditions, determine the angle (in degrees; accurate up to 2 digit behind the decimal point) over which the S/C rotates about a single axis when this torque acts on the S/C for 5 min.?
25.78

Q4

A 1 Newton resistojet uses nitrogen as propellant. Specific heat ratio of nitrogen is 1.4, molar mass is 28 gram/mole and nozzle pressure ratio is 10000. Determine the chamber temperature needed to achieve a true exhaust velocity 2500 m/s.
3240L
[Given; 2317, 2463, 941]

Q5

You are designing the propulsion system of a S/C with an initial wet mass of 1500kg. The mission characteristic velocity of this S/C is 2.8km/s. Given that the maximum acceleration of the vehicle is limited 10g (g=9.81 m/s^2) and that you select a constant thrust propulsion system capable of providing a specific impulse of 300s, you are asked to determine for this S/C the minimum thrust duration (in s; accurate up to 1 digit behind the decimal sign).
28.6

Q6

Put the following statements describing the Attitude control System design process in correct order;
2. Select type of spacecraft control by attitude control mode
1. Define control modes and system level requirements by control mode
4. Select & size attitude determination & control system hardware
6. iterate and document
5. Define attitude determination and control algorithms.
3. Quantify disturbance environments.

Q7

What type of control law is;
PD control
[Given; P, PID, Adaptive]

Q8
For a thermal rocket engine an increase in chamber pressure leads to an increase in true velocity.
False; As long as the nozzle area ratio does not change, the pressure ratio over the nozzle remains the same, so the true exhaust velocity does not change.

Q9
Given is an earth orbiting spacecraft with principle moments of inertia along the body axes of
Ixx= 100 kg-m^2
Iyy= 200 kg-m^2
Izz= 300 kg-m^2
For this S/C, we find that the gravity gradient disturbance torque is minimum in case..
The gravity gradient is equal for all three cases. (In case the satellite is exactly pointing to the centre of the Earth as was indicated in the first three answers, the gravity gradient disturbance torque is zero. So actually only this answer is correct)
[Given;If the satellite body x-axis is pointing exactly to the centre of the earth
If the satellite body y-axis is pointing exactly to the centre of the earth
If the satellite body z-axis is pointing exactly to the centre of the earth]

Q10
What is the mass of a 6000km long tether made from aluminum (mass density of 2.8 kg/ litre) with a diameter of 2.5mm?
82.5 tonnes
[Given; 8.25, 3300, 330]

Q11
The system specific impulse of a rocket system with a seperate energy source....
Reaches a maximum for a specific exhaust velocity.
[Given; increases with increasing exhaust velocity
decreases with increasing exhaust velocity
is independent from the exhaust velocity
varies with the energy source selected]

Q12
You are designing a solar sail propelled vehicle. You are considering a square solar sail with sides of 1 km, an absorptivity of 0.15 on the front (opposed to the sun) and thermally insulated back. Solar constant is 1400 W/m^2. what is the maximum acceleration force that the sail produces on a vehicle 2.1 AU from the Assuming that the sail is in thermal equilibrium?
9.1N

Q13
At lift-off the Ariane 5 space launcher is propelled by two solid rocket boosters each delivering 6.7 MN (meganewton) of thrust for 130 sec. The exhaust gases producing this thrust leave the engine with an effective velocity of 2650 m/s. Determine the total propellant mass (in kg) expelled during the operation of the two boosters.

657.000
[Given; 329.000, 3.224.000 ,67.000]

Q14
A small initially non-rotating spacecraft with mass moments of inertia of minimum 90 kg-m2 and maximum 120 kg-m2 attaches it self to a rotating vehicle that is spinning with 60 degrees per second about an axis with a mass moment of inertia of 30 kg-m2. The first vehicle has to reduce the rotational velocity of the compound vehicle to zero using a pair of equal thrusters, each with 50 cm moment arm. Compute the minimum thrust (in N; accurate up to two digits behind the decimal sign) that each thruster must produce when the rotational velocity must be reduced to 0 within 10 seconds. You may assume that the thrusters can be rotated such that they always fire opposite to
the spin direction.
Notice that this problem was included in one of the former exams.
12.57

Q15
In STP design a solar-thermal propulsion system is designed to provide a thrust of 0.05 N. Under the same assumptions as used in the STP design (see link), you are asked to calculate/ determine the mass (in gram) of the solar concentrator in case we design the system for a thrust of 5 mN and a specific impulse of 120 sec.
0.51 ?

Q16
A spherical propellant tank of the Globalstar S/C has a volume of 104 l and a mass of 6.4 kg. MEOP is 24.6 bar and tank safety factor is 2. What is the tank mass correction factor K in case the tank is made of titanium with a mass density of 4430 kg/m3 and a strength of 900 x 106 N/m2.
K = 1.7 ?
[Given; K = 0.6, K = 1.25, K = 1.3]

Q17
What is the order of the following activities in the design process of a propulsion system?
2. Establish requirements (if need be per manoeuvre)
1. Determine manoeuvres to be performed
3. Generate options for propulsion system
5. Compare options and make choice
4. Analyse propulsion system options
6. Evaluate choice, document and if need be iterate

Q18
Typical space propulsion tasks include:
changing the location of the orbit ascending node
Perigee kick manoeuvre
attitude control
unloading of reaction wheels
propellant settling
[Given; electrical power generation]

Q19
Calculate force (in mN; accurate up to 3 digits behind the decimal sign) due to solar pressure on a 2 m diameter spherical spacecraft covered with thermal protection material with a reflectivity of 0.8 at a distance of 0.5 AU. Tip: Solar intensity may be calculated using the relation 11.1 from the book Spacecraft Systems Engineering.
0.092

Q20
The International Space Station has two different attitude modes; 1) inertial pointing during assembly phases or 2) nadir pointing (z-axis towards the centre of the Earth) for certain scientific experiments.
•slew angular rate: 0.4 degree per second.
•time to reach desired slew rate: 5 seconds.
•moment of inertia about slew axis: 108 kg-m2
•moment arm (thruster to c.g.): 30m
Calculate the minimum thrust (in N, per thruster and accurate up to 1 digit behind the decimal sign) needed to slew the ISS in case we use a pair of thrusters, which are firing opposite of each other to cancel linear accelerations.
Notice that this problem was included in the March 2008 exam.
2327.1

Q21
Match the following disturbance torques and their dependance from earth
C. Aerodynamic
B. Gravity gradient
A. Solar radiation

Q22
The cryogenic main stage of the Ariane 5 launcher produces a thrust of 1.15 MegaNewton. The average (over the altitude range) specific impulse is 420 sec. What is the jet power produced by this engine?
2.4 GigaWatt
[Given; 240 MegaWatt, 0.5 GigaWatt, 50 MegaWatt]

Q23
A disadvantage of Gravity-gradient control is that it is limited to 1 or 2 possible orientations
True

Q24
What do we mean by controlling the attitude of a SC?
Orienting the spacecraft in a specified, predetermined direction
[Given; Control of the azimuth of the spacecraft
Control of the elevation of the spacecraft
Control of the rotation about the x-axis of the spacecraft]

Q25
Repointing for a S/C is referred to as slewing the S/C. The slew rate is given in dimensions rad/s or degrees/s and is associated with the change in position over time of an object which orbits around the observer.
False

Q26
A sun-pointing satellite in LEO with no inclination can be stabilized using the gravity gradient torque.
False

Q27
What is the most important source of disturbance torques for GEO satellites?
Solar radiation
[Given; Gravity gradient
Magnetic field
Aerodynamic forces]

Q28
For a space mission, the orbital analyst has indicated a mission characteristic velocity of 4000 m/s. To limit vehicle mass to 2 ton, you are considering the use of a non-rocket based propulsion system capable of delivering a constant thrust of 0.14 N. Given that no disturbances act upon the vehicle (gravity losses have been taken into account in the mission characteristic velocity), you are asked to calculate the time (in years; accurate up to two digits behind the decimal sign) it takes for the vehicle to achieve the required velocity change.
1.81