TEST EXAM
INTRODUCTION BUILDING PHYSICS AND MATERIAL SCIENCE
7S3X0

1 MATERIALS SCIENCE (Q1-4)

Q1. Which statement is correct?

A) Hooke's law describes some materials return to their original shape after removal of the exerted stress and Young's modulus has unit [N].
B) Hooke's law describes that stress is linearly proportional to strain and Young's modulus has unit [N/m^2].
C) Hooke's law describes stress is exponentially proportional to strain and Young's modulus is dimensionless.
D) Hooke's law describes a material does not return to its original shape after removal of the exerted stress and Young's modulus has unit [N/m^2].

Q2. Ordinary Portland cement consists of

A) C_3A, C_3S, C_2S and gypsum.
B) C_3A, C_2S and slag.
C) C_3A, C_2S, C_4S and gypsum.
D) C_3S, C_2S, fly ash and gypsum.

Q3. During the oxygen process

A) nitrogen is added.
B) pig iron is produced.
C) pork iron is produced.
D) steel is produced.

Q4. UV degradation of polymers is caused by

A) low pH.
B) high pH.
C) free radicals.
D) hydrolysis.

2 LIGHTING (Q5-13)

Q5. What statement about light is correct?

A) Radiant energy with a wavelength of 555 nm is considered light
B) Radiant energy with a wavelength between 250 and 380 nm is considered light
C) Radiant energy with a wavelength between 780 nm and 1000 nm is considered light
D) Radiant energy with a wavelength between 250 and 1000 nm is considered light.

Q6. What is the correct unit for luminous intensity?

A) lx
B) cd/m^2
C) lm
D) cd

Q7. For a working space with a window positioned in the facade, facing north, the average horizontal daylight factor at work plane position is 13%. For an optimal use of daylight, certain rules of thumb can be used. According to one of those rules of thumb:

A) Glare protection is almost certainly necessary
B) For good daylighting, a little additional electrical lighting is required
C) To create a day-lit space, additional electrical lighting is required
D) The space feels dark; additional electrical lighting is required almost continuously.

Q8. A very thin, diffuse reflecting wall of a building has a luminous absorption of 20% and a luminous transmittance of 10%. The illuminance on the walls is 32 000 lx. The luminance of the wall is

A) ~2 037 cd/m^2
B) ~6 400 cd/m^2
C) ~7 130 cd/m^2
D) ~22 400 cd/m^2

Q9. Given is a CIE overcast sky with a zenith luminance is 25 000 cd/m^2. What is the luminance of the sky at the point with an azimuth angle of 230° and an elevation angle of 25°?

A) ~8 333 cd/m^2
B) ~15 377 cd/m^2
C) ~21 131 cd/m^2
D) ~23 438 cd/m^2

Q10. For a uniform sky condition one can determine the

A) Contribution of the daylight in a room for diffuse sky and direct sunlight
B) Contribution of the daylight in a room due to the diffuse sky
C) Contribution of the daylight in a room due to the direct sunlight
D) Daylight factor on a certain position in a room

Q11. An architect wants the glazed area of a room to be 4 m^2. The room is 3 m wide, 6 m deep and 3 m high. Which of the following glazing types would you recommend?

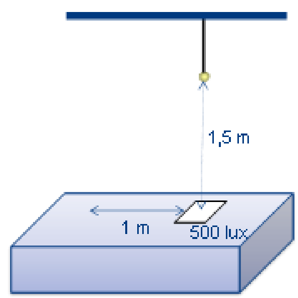
A) Glazing A with a luminous transmittance of 0.2.
B) Glazing B with a luminous transmittance of 0.4.
C) Glazing B with a luminous transmittance of 0.6.
D) Glazing B with a luminous transmittance of 0.8.

Q12. What components contribute to the daylight factor inside a room?

A) Direct sun component, exterior reflections and interior reflections
B) Direct sky component and diffuse sky components
C) Sky component, exterior reflections and interior reflections
D) Direct sun component and diffuse sky component

Q13. Given is a point light source as shown in the image below. It creates an illuminance of 500 lx on the area directly below. What luminous intensity would be required to create 500 lx 1m away from that point?

A) 1125 cd
B) 1352 cd
C) 1625 cd
D) 1953 cd



3 HEAT (Q14-22)

Q14. One important part of the heat loss calculation is the thermal resistance of the construction. The unit of thermal resistance is:

A) W/m^2
B) W/m^2K
C) W/mK
D) m^2K/W

Q15. Lowering the indoor temperature setpoint with 2°C will have an effect on the energy loss over a heating season of about

A) 3%
B) 7%
C) 11%
D) 15%

Q16. Consider winter conditions (θ_e = -7°C) and a construction in which a thermal bridge is present. Compared to a case without thermal bridge:

A) The heat transfer is larger and the exterior surface temperature lower
B) The heat transfer is larger and the interior surface temperature is higher
C) The heat transfer is larger and the exterior surface temperature is higher
D) The heat transfer is lower and the interior surface temperature is lower

Q17. If we consider a thermal steady state situation in a multi-layered construction, we can state that:

A) The heat flow in each single layer is not equal
B) The heat flow in each single layer is equal
C) The temperature difference over each layer is equal
D) The total conductance is the sum of the separate conductance of each single layer

Q18. The glazing of a climate façade is usually as follows:

A) A climate façade has external double glazing and internal single glazing
B) A climate façade has external double glazing and internal double glazing
C) A climate façade has external single glazing and internal single glazing
D) A climate façade has external single glazing and internal double glazing

Q19. Suppose you would like to insulate a massive stone external wall of a non-insulated building. To make efficient use of the thermal storage capacity of the constructions:

A) Thermal insulation is best placed on the exterior of the wall.
B) The place of the thermal insulation does not matter.
C) Thermal insulation is best placed on the inside of the wall.
D) The type of insulation material is more important than its position.

Q20. Calculate the total thermal transmittance value of a wall, consisting from inside to outside of:
100 mm bricks; thermal conductivity k = 0.8 W/mK
120 mm mineral wool, thermal conductivity k = 0.04 W/mK
100 mm bricks, thermal conductivity k = 1.1 W/mK
The internal transfer coefficient h_i = 7 W/m²K, the external transfer coefficient h_e = 25 W/m²K.
No cavity is present.

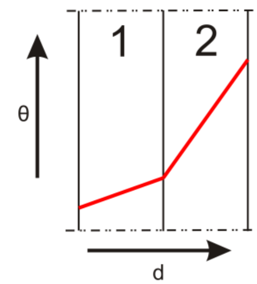
A) 0.0003 W/m²K
B) 0.028 W/m²K
C) 0.29 W/m²K
D) 0.31 W/m²K

Q21. Consider a wall construction with a total thermal transmittance value U of 0.25 W/m^{2}K. During winter the indoor temperature θ_i = 20°C, the outdoor temperature θ_i = -10°C. The external transfer coefficient is h_e = 25 W/m^{2}K, the internal transfer coefficient h_i = 7 W/m^{2}K.
The surface temperature at the exterior side of the wall equals:

A) -8.6 °C
B) -9.7 °C
C) -9.2 °C
D) -8.9 °C

Q22. The figure on the right shows a temperature profile through a double-layer construction. Based on this figure one can state that:

A) Thermal conductivity is larger in layer 1
B) Thermal conductivities are equal
C) Thermal conductivity is larger in layer 2
D) Figure does not provide sufficient information to draw conclusion



4 SOUND (Q23-31)

Q23. What does p_{eff} mean in the equation of the sound pressure level $L_p = 10\log_{10}(p_{eff}^2/p_0^2)$?

A) Sound pressure at 1 m from the source;
B) Diffuse field sound pressure;
C) Root mean square of the sound pressure over a certain period of time;
D) Sound pressure threshold of hearing.

Q24. Two different loudspeakers each produce a sound pressure level of 83 dB at the listeners' position. The background sound pressure level is 70 dB at the listeners' position. What is the total sound pressure level at the listeners' position due to the two loudspeakers and the background noise?

A) 70 dB;
B) 83 dB;
C) 86 dB;
D) 87 dB.

Q25. Where in the human ear are vibrations transferred in different frequency components?

A) The inner ear;
B) The middle ear;
C) The outer ear;
D) In none of the ear sections of a), b) and c).

Q26. What is true about A-weighting for hearing sensitivity?
A) We are most sensitive at 125 Hz;
B) We are most sensitive at 500 Hz;
C) We are most sensitive at 1000 Hz;
D) We are most sensitive at 4000 Hz.

Q27. A machine produces a noise level of 80 dB for 30 minutes, and is then silent (0 dB noise production) for 30 minutes. What is the equivalent sound pressure level over the total time duration of 60 minutes?
A) 40 dB;
B) 74 dB;
C) 77 dB;
D) 80 dB.

Q28. What are the units of the sound intensity level L_I and the sound power W?
A) L_I in [dB], W in [dB];
B) L_I in [dB], W in [W];
C) L_I in [W/m^2], W in [dB];
D) L_I in [W/m^2], W in [W].

Q29. What is true about the sound transmission index R of a building element as measured in laboratory conditions?
A) R is dependent on the frequency;
B) R is dependent on the size of the building element;
C) R is dependent on the sound absorption of the receiving room;
D) R is dependent on the sound power of the loudspeaker used.

Q30. Consider a double wall system. What happens with the sound transmission index R below the mass spring resonance frequency f_0?
A) R is 3dB lower than R of an equally heavy single leaf construction;
B) R is equal to R of an equally heavy single leaf construction;
C) R is 3dB higher than R of an equally heavy single leaf construction;
D) R is cannot be related to R of an equally heavy single leaf construction.

Q31. Consider a single wall system. What determines the sound transmission index R below the critical frequency fc (but above the first eigenfrequency of the wall)?
A) R depends on bending stiffness and material damping;
B) R depends on mass and material damping;
C) R depends on bending stiffness and frequency;
D) R depends on mass and frequency.

5 MOISTURE (Q32-40)

Q32. Condensation at a surface occurs when the surface temperature is lower than:

A) the dry bulb temperature
B) the dewpoint temperature
C) The operative temperature
D) The ambient air temperature

Q33. A room is ventilated at an air exchange rate of 1.2 h^{-1}. The room has a volume of 5 x 5 x 2.5 m^3. The density of air is assumed to be 1.225 kg/m^3 and the indoor and outdoor water vapor ratios are: x_e = 2 g/kg and x_i = 10 g/kg. The vapor transport by air flow is equal to:

A) 0.47 kg/s
B) 0.204 kg/s
C) 2.04 10^{-4} kg/s
D) 2.04 10^{-4} g/s

Q34. Air with a dry bulb temperature of 22°C and a relative humidity of 50% is cooled. What is the dewpoint temperature?

A) 9°C
B) 11°C
C) 19°C
D) 22°C

Q35. A vapor barrier at the inside of a structure can cause condensation problems when

A) the indoor temperature is higher than outdoors
B) the outdoor temperature is higher than indoors
C) the indoor and outdoor temperatures are the same and rather low
D) the indoor and outdoor temperatures are the same and rather high

Q36. Mold grow will occur at a surface

A) only if the surface becomes wet by condensation
B) only if the air humidity exceeds 80 % RH
C) only if the air humidity exceeds 80 % RH for a longer period of time
D) only if the air humidity exceeds 60 % RH

Q37. In Havana (Cuba) the outdoor conditions are an outdoor air temperature of 30°C and the related relative humidity is equal to 75%. The indoor conditions in an office room are controlled by an HVAC system at an indoor air temperature of 21°C and a relative humidity of 60%.
The dewpoint temperature of the outdoor air is equal to:

A) 12.9 °C
B) 21.0 °C
C) 24.1 °C
D) 25.1 °C

Q38. The owner of the office building in Havana (see previous question) decides to have the vapor barrier according to Dutch conditions: 1 mm steel with an infinite vapor resistance at the interior (k = 50 W/mK, $\mu d \to \infty$), an insulating material of 80 mm (k = 0.03 W/mK, $\mu = 2$) and a relatively vapor open finishing of a wooden material (d = 22 mm, k = 0.2 W/mK, $\mu = 20$). The surface heat transfer coefficients at the interior and the exterior are respectively h_i = 7 and h_e = 25 W/m^{2}K.
Calculate the surface temperature at the interface between the steel sheets and the insulation layer.

A) 29.6 °C
B) 28.4 °C
C) 21.4 °C
D) 21.6 °C

Q39. The vapor conductivity of stagnant air equals $\delta_a = 1.8 \cdot 10^{-10}$s. Calculate the vapor pressure at the interface of steel/insulation material.
The vapor pressure at the interface of steel/insulation material leads to condensation and equals

A) 2530 Pa
B) 2555 Pa
C) 2625 Pa
D) 2810 Pa

Q40. The quantity of internal condensation per m^2 per month equals (30 days):

A) 359 g
B) 488 g
C) 526 g
D) 618 g

6 FORMULAE:

6.1 7S3X0 IBPM – PART LIGHTING

$A_{screen/text} : A_{task\ area} : A_{working\ environment} : A_{daylight\ opening/\ artificial\ lighting} = 1 : 3 : 10 : 20/40$	
$0.2 \leq \tau \cdot WWR \leq 0.3$	$C = \frac{Lmax}{Lmin}$
$C = \frac{L_0 - L_b}{L_b}$	$d = 23.46° \cdot \sin\left(2\pi \cdot \frac{284+n}{365}\right)$
$E = \frac{I}{r^2} \cdot \cos \varepsilon_2$	$E_h = \frac{7\pi}{9} \cdot L_z$
$E_h = \pi \cdot L_0$	$E_v = \frac{3\pi+8}{18} \cdot L_z$
$E_v = \frac{\pi}{2} \cdot L_0$	$L(\alpha, \theta) = L_z \cdot \frac{1+2 \cdot \sin\theta}{3}$
$L = E \cdot \frac{\rho}{\pi}$	$L_z = L_0 = L_{(\alpha,\theta)}$
$L_z = 90 \frac{cd}{m^2} + 9630 \frac{cd}{m^2} \cdot (\sin \gamma_S)^{1.19}$	$M_{total} = \varepsilon \cdot \sigma \cdot T^4$
$u = t \cdot 15°$	$\gamma = \sin^{-1}(\sin\varphi \cdot \sin d - \cos\varphi \cdot \cos d \cdot \cos u)$
$\lambda_{max} \cdot T = b$	$\tau(\lambda) = \frac{\Phi_\tau(\lambda)}{\Phi_0(\lambda)}$
$\tau_{UV} = \frac{\int_{300\ nm}^{380\ nm} \Phi_\tau(\lambda)\, d\lambda}{\int_{300\ nm}^{380\ nm} \Phi_0(\lambda)\, d\lambda}$	$\tau_e = \frac{\int_{300\ nm}^{2500\ nm} \Phi_\tau(\lambda)\, d\lambda}{\int_{300\ nm}^{2500\ nm} \Phi_0(\lambda)\, d\lambda}$

6.2 7S3X0 IBPM – PART ACOUSTICS

$\alpha = \tau + \delta$	$L_{p1+2} = 10log_{10}\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}}\right)$
$L_{eq} = 10log_{10}\left(\frac{1}{T}\sum_{i=1}^{n} t_i \cdot 10^{\frac{L_{p,i}}{10}}\right)$	$T = \frac{1}{6}\frac{V}{A} \approx 0{,}16\frac{V}{A}$
$R = 10\lg\frac{I_i}{I_\tau} = 10\lg\frac{1}{\tau}$	$R_{vlak} = -10\lg\left[\frac{1}{S_{vlak}}\left(S_1 10^{\frac{-R_1}{10}} + S_2 10^{\frac{-R_2}{10}} + ..\right)\right]$
$R = L_1 - L_2 + 10\lg\frac{S}{A_2}$	$R = 20\lg\frac{\omega m}{2\rho c}$
$f_0 = \frac{c}{2\pi\cos\theta}\sqrt{\left[\frac{\rho}{d}\left(\frac{1}{m_1} + \frac{1}{m_2}\right)\right]}$	$f_0 = \frac{120}{\sqrt{m_{tot}\, d}}$

6.3 7S3X0 IBPM – PART HEAT AND MOISTURE

$Q_{hr} = (\Sigma \alpha_k U_k A_k + \rho c_p \dot{V})(\theta_i - \theta_e) t \cdot 10^{-6} - \eta_u (q_{\text{int}} A_g t \cdot 10^{-6} + z_w A_w g E_s)$	
$q_{cd} = \frac{\lambda(\theta_1 - \theta_2)}{d}$	$R_a = R_i + R_c + R_e$
$U = \frac{1}{R_a}$	$\Phi_t = AU(\theta_1 - \theta_2)$
$E_{dir,hor} = E_{\perp} \sin h$	$E_{dir,vert} = E_{\perp} \cos h$
$\Phi_s = AgE_s$	$\Phi_{ij} = \Sigma A_k U_k (\theta_i - \theta_j) + \rho c_p \dot{V}_{ji} (\theta_i - \theta_j)$
$G = \rho_a \dot{V}(x_i - x_e)$	$\Phi_v = \rho c_p \dot{V}(\theta_i - \theta_e)$
$G = \rho_a \frac{nV}{3600}(x_i - x_e)$	$G = A\beta_x (x_i - x_{si})$
$\Phi_{cv} = Ah_{cv}(\theta_i - \theta_{si})$	$\beta_x = (Le)^{n-1} \frac{h_{cv}}{c_p} \approx 1{,}1 \cdot 10^{-3} h_{cv}$
$f = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e}$	$\delta_a = 1.8 \cdot 10^{-10} (kg / smPa \equiv s)$
$Z = \frac{\Delta p}{g_v}$	$Z = \frac{\mu d}{\delta_a}$
$\theta_j = \theta_e + (\theta_i - \theta_e) \frac{\sum_{i=1}^{j} R_{ci}}{R_a}$	$p_j = p_e + (p_i - p_e) \frac{\sum_{i=1}^{j} \mu d_i}{\mu d_{tot}}$
$g_{in} = \frac{p_i - p_{sat}}{Z_i}$ and $g_{out} = \frac{p_{sat} - p_e}{Z_e}$	$\Phi = AL\beta_p \left(p_{air} - p_{sat}(\theta_s) \right)$
$v = \frac{dx}{dt} = \frac{r^2}{8\eta} \cdot \frac{\Delta p}{x}$	$x = \left(\frac{\sigma r}{2\eta} \right)^{\frac{1}{2}} \sqrt{t}$ and $v = \frac{\left(\frac{\sigma r}{8\eta} \right)^{\frac{1}{2}}}{\sqrt{t}}$

Table: Saturation pressure of vapor p_{sat} (Pa) and saturated humidity ratio x_{sat} (g per kg dry air)

θ (˚C)	p_{sat} (Pa)	x_{sat} (g/kg)	θ (˚C)	p_{sat} (Pa)	x_{sat} (g/kg)
-20	103	0.63	15	1,706	10.6
-19	114	0.70	16	1,818	11.4
-18	125	0.77	17	1,938	12.1
-17	137	0.85	18	2,065	12.9
-16	150	0.93	19	2,197	13.8
-15	165	1.01	20	2,340	14.7
-14	181	1.11	21	2,487	15.6
-13	198	1.22	22	2,645	16.6
-12	217	1.34	23	2,810	17.7
-11	237	1.46	24	2,985	18.8
-10	260	1.60	25	3,169	20.0
-9	284	1.75	26	3,362	21.4
-8	310	1.91	27	3,566	22.6
-7	338	2.08	28	3,781	24.0
-6	368	2.27	29	4,006	25.6
-5	401	2.47	30	4,244	27.2
-4	437	2.69	31	4,491	28.8
-3	476	2.94	32	4,753	30.6
-2	517	3.19	33	5,029	32.5
-1	562	3.47	34	5,318	34.4
0	611	3.78	35	5,621	36.6
1	657	4.07	36	5,940	38.8
2	705	4.37	37	6,274	41.1
3	759	4.70	38	6,624	43.5
4	813	5.03	39	6,991	46.0
5	872	5.40	40	7,372	48.8
6	935	5.79	41	7,785	51.8
7	1,002	6.21	42	8,205	54.8
8	1,073	6.65	43	8,645	58.0
9	1,148	7.13	44	9,106	61.4
10	1,228	7.63	45	9,590	65.0
11	1,313	8.15	46	10,090	68.8
12	1,403	8.75	47	10,615	72.8
13	1,498	9.35	48	11,164	77.0
14	1,599	9.97	49	11,737	81.5