HUT, TUT, LUT, UO, ÅA, UT and UW entrance examination in physics for the engineering departments 31.5.2006 Series A

Write your name and applicant number on each paper. Solve each problem on a separate sheet of paper and explain briefly the formulas you use.

A1 A flywheel has been planned for buses to store part of the kinetic energy of the bus during braking. This energy is then used when the bus accelerates. A bus with a velocity 41 km/h brakes and stops at a bus stop. Determine the angular velocity of the flywheel after the braking. The initial rotation speed of the flywheel before the braking was 110 rotations per minute and 72 % of the initial kinetic energy of the bus can be converted into kinetic energy of the flywheel. The moment of inertia of the flywheel is 26.0 kgm^2 and the mass of the bus is 18500 kg.

A2 A balloon filled with helium should carry a load of 291 kg, i.e. the balloon pilot, the balloon cloth and all equipment. The temperature of the surrounding air is 11.0 °C and the pressure is 102.2 kPa. Determine the mass of the helium required to lift the balloon from the ground. Assume that the temperature and pressure for the helium are equal to the corresponding values for the surrounding air.

A3 A piece of ice, at a distance $l = 2.50$ m from the eaves of a frictionless inclined tin roof, starts to glide down. The inclination of the roof is $\alpha = 32.0°$ and the eaves of the roof are at a hight $h = 10.0$ m (Figure 1).
a) What is the velocity (size and direction) for the piece of ice when it hits the pavement? (4 p.)
b) How far from the wall does the piece of ice hit the pavement? The eaves reach out $r = 0.400$ m from the wall. (2 p.)

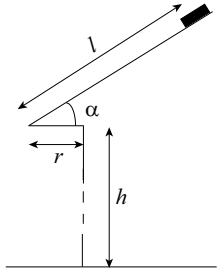

Figure 1

A4 When you use a concave make-up or shaving mirror (focal length $f = 34.0$ cm), you want the magnified image the right way up 25.0 cm from your face.
a) Draw a figure that shows how the mirror image is formed.
b) What is the distance between the mirror and the face in this case?

A5 Seven lightbulbs are connected in series in an electrical chandelier. The nominal voltage for each bulb is 34 V and the nominal power 3.0 W.
a) Calculate the resistivity for one of the lightbulbs. (2 p.)
b) Three of the lightbulbs break and they are replaced by mistake with faulty bulbs, with a nominal voltage of 34 V and nominal power of 4.5 W. The chandelier is connected to an electrical network with a voltage of 230 V. Determine the power now used by each of the original lightbulbs and by each of the new lightbulbs. (4 p.)

A6 When uranium undergoes fission, the isotope $^{235}_{92}$U ($m_{\mathrm{U}} = 235.043930$ u) absorbes a neutron and becomes unstable. The nucleus rapidly decays into two new nuclei. In an example reaction the thus created daughter nuclei are $^{140}_{54}$Xe ($m_{\mathrm{Xe}} = 139.92164$ u) and $^{94}_{38}$Sr ($m_{\mathrm{Sr}} = 93.915361$ u).
a) Write the full reaction equation for this nuclear reaction.
b) Determine the energy per $^{235}_{92}$U unit mass [J/kg] that can be released from the nuclear fuel if only the fission reaction described above took place.

CONSTANTS:

Absolute zero point	T_0	$= -273.15$ °C	Molar mass of air	M_{a}	$= 29.0$ g mol^{-1}
Acceleration of gravity	g	$= 9.807$ m s^{-2}	Molar mass of helium	M_{He}	$= 4.00$ g mol^{-1}
Atomic mass unit	u	$= 1.6605 \cdot 10^{-27}$ kg	Neutron rest mass	m_n	$= 1.008665$ u
Avogadro's number	N_A	$= 6.0221 \cdot 10^{23}$ mol^{-1}	Normal air pressure	p_0	$= 1.013 \cdot 10^5$ Pa
Electron rest mass	m_e	$= 5.4857990 \cdot 10^{-4}$ u	Permittivity of vacuum	ε_0	$= 8.8542 \cdot 10^{-12}$ F m^{-1}
Elementary charge	e	$= 1.6022 \cdot 10^{-19}$ C	Planck's constant	h	$= 6.6261 \cdot 10^{-34}$ Js
Gas constant	R	$= 8.3145$ J mol^{-1}K^{-1}	Speed of light in vacuum	c	$= 2.998 \cdot 10^8$ m s^{-1}