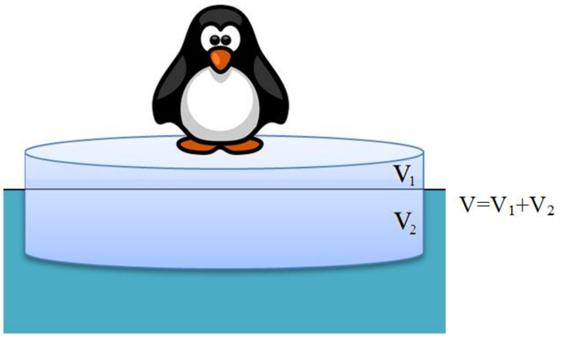
P H Y S I C S , G R A D E 1 0

1. An ice floe which height is 20 cm and cross-sectional area 1.5 m^2 floats in the ocean. Ice density is 900 kg/m^3, water density is 1030 kg/m^3, acceleration of gravity is 10 m/s^2.



a. Draw all forces.
b. Calculate the gravity force of the ice floe.
c. What Archimedes force will act the ice floe?
d. Calculate the percentage of the ice floe volume (V_1) which is above the water?
e. What is the maximum mass of penguin which can stand on the ice floe and his feet will be dry?

Solution:

a) drew correctly	**1 mark**
b) $F_g = mg = \rho_{ice}Vg = \rho_{ice}Shg$ $F_g = 900 * 1.5 * 0.2 * 10 = 2700\ N$ $F_g = 2.7\ kN$	**1 mark** **1 mark**
c) $F_A = 2.7\ kN$	**1 mark**
d) $\rho_{H2O} \cdot g \cdot V_2 = \rho_{ice} \cdot g \cdot V$ $V_2 = \frac{\rho_{ice} \cdot g \cdot V}{\rho_{H2O} \cdot g} = \frac{\rho_{ice} \cdot S \cdot h}{\rho_{H2O}}$ $\frac{V_1}{V} = \frac{V - V_2}{V} = 1 - \frac{V_2}{S \cdot h} = \frac{\rho_{ice}}{\rho_{H2O}}$ $\frac{V_1}{V} = 1 - \frac{900}{1030} = 0.13$ $\frac{V_1}{V} = 13\%$	**1 mark** **1 mark** **1 mark**
e) $m = \frac{F_{Amax} - F_g}{g}$ $F_{Amax} = \rho_{H2O} \cdot g \cdot V = \rho_{H2O} \cdot g \cdot S \cdot h$ $m = \frac{(\rho_{H2O}Sh - \rho_{ice}Sh)g}{g} = Sh(\rho_{H2O} - \rho_{ice})$ = 39 kg.	**1 mark** **1 mark** **1 mark**

2. A piece of ice which mass is 200 g and temperature is –10 °C is in the calorimeter. The leaden ball which temperature is 200 °C is put on this piece of ice. 90% ice and 10% water remained in the calorimeter when the thermodynamic equilibrium steadied.

Material	**Specific heat (*c*),** $\frac{J}{kg \cdot °C}$	**Density (ρ),** $\frac{kg}{m^3}$	**Specific heat of melting (λ),** $\frac{J}{kg}$
Lead	138	11 400	
Water	4200	1000	
Ice	2100	900	$3.3 \cdot 10^5$

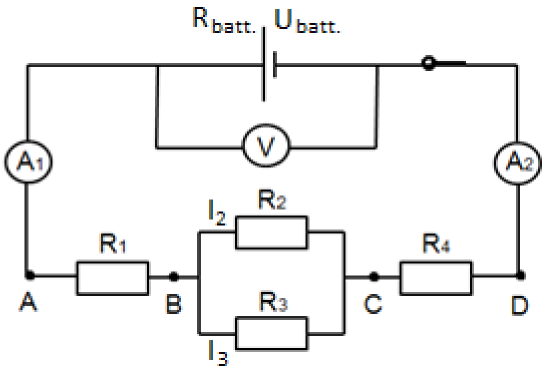
a. Calculate the radius of the ball.

b. The second ball of the same temperature is additionally placed on the ice. The remaining ice melts and the water heats up to 10 °C. Calculate the radius of the second ball. (Ignore the steaming).

Solution:

a) After inserting the ball 10% ice melted and the temperature stabilized to $t_0 = 0$ ° C.	
$$c_{ice} m_{ice}(t_0 - t_{ice}) + \lambda_{ice} 0.1m = c_{ball} m_{ball1}(t - t_0)$$	**1 mark**
$$m_{ball1} = V_{ball1} \cdot \rho_{ball} = \frac{4}{3}\pi r_{ball1}^3 \cdot \rho_{ball}$$	**1 mark**
$$r_{ball1} = \sqrt[3]{\frac{c_{ice} m_{ice}(t_0 - t_{ice}) + \lambda_{ice} 0.1m}{\frac{4}{3}\pi \rho_{ball} c_{ball}(t - t_0)}}$$	**1 mark**
$r_{ball1} = 1{,}5$ cm	**1 mark**
b) After inserting the second ball remaining ice will melt. The water and the first ball will heat up to temperature $t_1 = 10$ ° C.	
$$\lambda_{ice} 0.9m + c_{H2O} m_{H2O}(t_1 - t_0) + c_{ball} m_{ball1}(t_1 - t_0) = c_{ball} m_{ball2}(t - t_1)$$	**2 marks**
$$m_{ball2} = V_{ball2} \cdot \rho_{ball} = \frac{4}{3}\pi r_{ball2}^3 \cdot \rho_{ball}$$	**1 mark**
$$m_{ball1} = V_{ball1} \cdot \rho_{ball} = \frac{4}{3}\pi r_{ball1}^3 \cdot \rho_{ball} = 0.16 \text{ kg}$$	
$$r_{ball2} = \sqrt[3]{\frac{\lambda_{ice} 0.9m + c_{H2O} m(t_1 - t_0) + c_{ball} m_{ball1}(t_1 - t_0)}{\frac{4}{3}\pi \rho_{ball} c_{ball}(t - t_1)}}$$	**2 marks**
$$r_{ball2} = 3.7\ cm$$	**1 mark**

3. Electric circuit consists of a 12 V and 2 Ω battery and conductors whose resistances are $R_1 = 1\ \Omega$, $R_2 = 2\ \Omega$, $R_3 = 5\ \Omega$, $R_4 = 4\ \Omega$.



a. Calculate the total resistance of the electric circuit.

b. What the amperemeter A_1 will show? Amperemeter A_2?

c. Calculate the current I_2 flowing through the resistor R_2.

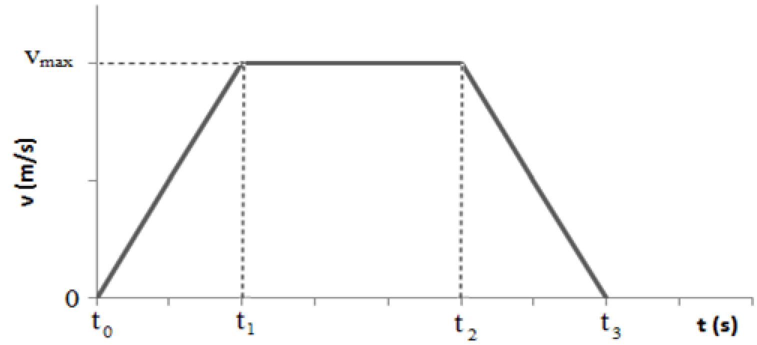
d. Compare voltage between points AB and BC $\left(\frac{V_{AB}}{V_{BC}}\right)$

e. Calculate the current of the short-circuit.

Solution:

a) $R = R_{batt.} + R_1 + R_{23} + R_4$, $R_{23} = \frac{R_2 R_3}{R_2 + R_3}$, $R = 8.43\ \Omega$	**1 mark** **1 mark**
b) $I = I_{A1} = I_{A2}$ $I = \frac{U_{batt.}}{R} = 1.42$ A	**1 mark**
c) $I_2 R_2 = I_3 R_3$, $I_3 = \frac{I_2 R_2}{R_3}$, $I = I_2 + I_3 = I_2 + \frac{I_2 R_2}{R_3} = \frac{I_2(R_2+R_3)}{R_3}$ $I_2 = \frac{I R_3}{(R_2 + R_3)} = 1\ A$	**1 mark** **2 marks** **1 mark**
d) $\frac{V_{AB}}{V_{BC}} = \frac{I R_1}{I_2 R_2} = 0.71$.	**2 marks**
e) $I_{max} = \frac{V_{batt.}}{R_{batt.}} = 6\ A$	**1 mark**

4. The bus 2 km distance between stations travels over 140 s. The maximum velocity of the bus is 16 m/s. The accelerations in the beginning and at the end of the distance are identical.



a. Calculate the distances S_1, S_2, S_3.

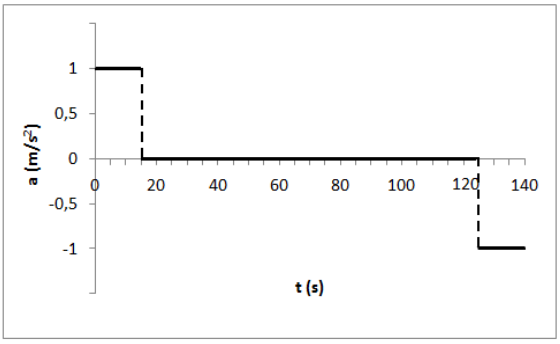
b. Calculate the accelerations a_1, a_2, a_3 at all times intervals.

c. Draw the graph of the acceleration dependence on time.

d. How many turns the 70 cm diameter wheels of the bus made to a full stop when the bus began to stop in the distance S_3?

Solution:

a) $S_1 = \frac{a_1(t_1 - t_0)^2}{2}, \quad v_{max} = a_1(t_1 - t_0),$ $S_1 = \frac{v_{max}(t_1 - t_0)}{2}$ $S_2 = v_{max}(t_2 - t_1)$ $S_3 = S_1 = \frac{v_{max}(t_1 - t_0)}{2}$	**1 mark**
$S = S_1 + S_2 + S_3 = v_{max} t_2, \quad t_2 = t_3 - t_1$ $S = v_{max}(t_3 - t_1),$ $t_1 = t_3 - \frac{S}{v_{max}} = 15\ s,$ $t_2 = t_3 - t_1 = 125\ s$	**1 mark**
$S_1 = S_3 = \frac{v_{max}(t_1 - t_0)}{2} = 120\ m$ $S_2 = v_{max}(t_2 - t_1) = 1760\ m$	**1 mark**
b) $a_1 = \frac{v_{max}}{t_1}, \quad a_3 = -a_1$	**1 mark**
$a_1 = 1\ m/s^2, \ a_2 = 0\ m/s^2, \ a_3 = -1\ m/s^2,$	**1 mark**

c) 	**0.5 mark** if diagram is $a = f(t)$ [*not* $t = f(a)$] **0.5 mark** for the correct axis titles (names) **0.5 mark** for the correct scale interval **0.5 mark** for the correct curve
d) $S = N \cdot \pi \cdot D$ $S_3 = 120$ m. $N = \frac{S_3}{\pi D} = 54.6$	**2 mark** **1 mark**