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## **IZOTERMNA IN IZOHORNA PLINSKA SPREMEMBA**

Preveri veljavnost Boylovega zakona (izotermna plinska sprememba) in Amontonsovega zakona (izohorna plinska sprememba) za zrak.

Pripomočki:

* + brizga
	+ senzor za tlak
	+ računalniški vmesnik Vernier
	+ termometer
	+ kalorimeter z grelcem

BOYLOV ZAKON

1. Navodilo:

* + volumen zraka v brizgi naj bo približno 10 ml
	+ brizgo nežno privij na merilnik tlaka in pazi, da ne zlomiš nastavka na merilniku
	+ merilnik priključi na računalniški vmesnik
	+ način merjena vmesnika spremeni v zajemanje dogodkov (*Events with Entery*)
	+ prični z maritvijo (zelena puščica)
	+ vnesi meritev v vmesnik (gumb *Keep*) in zapiši vrednsoti tlaka in volumna na list
	+ počasi zmanjšaj volumen za 1 ml in vnesi meritev
	+ volumen zmanjšuj po 1 ml do vrednosti 5 ml; sproti vnašaj meritve
	+ pusti, da se brizga vrne na vrednost 10 ml; zdaj večaj volumen po 1 ml do vrednosti 15 ml
	+ izračunaj produkte tlaka in volumna za posamezen par meritev in ugotovi, ali je vrednost konstantna v okviru napake merjenja
	+ skozi točke grafa na vmesniku potegni krivuljo, ki se najbolje prilega (*Analiza -> Prilagoditvene krivulje -> Power*); na list nariši p-V diagram
1. Izmerki in rezultati:

|  |  |  |  |
| --- | --- | --- | --- |
|  | $V$[ml] | $p$ [kPa] | $pV$ [ml kPa] |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |

Katera funkcija se najbolje prilega točkam v grafu?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

AMONTONSOV ZAKON

1. Navodilo:

* + merilnik priključi na vmesnik, način merjenja vmesnika spremeni v zajemanje dogodkov (*Events with Entery*)
	+ zamašek pritrdi na merilnik tlaka in z njim zamaši elenmajerico
	+ v kalorimeter nalij vodo, v vodo daj elenmajerico, grelnik in termometer
	+ počakaj nekaj minut, da se med zrakom in vodo vzpostavi termično ravnovesje
	+ prični z meritvijo
	+ odčitaj začetno temperaturo in meritev (tlak izmeri vmesnik) vnesi v vmesnik (gumb *Keep*)
	+ vključi grelnik
	+ počakaj, da temperatura naraste za dve stopinji in ponovno vnesi meritev
	+ izvedi vsaj pet meritev
	+ skozi točke na grafu potegni krivuljo, ki se jim najbolje prilega (*Analiza -> Prilagoditena krivulja*)
	+ vrednsoti tlaka in temperature prepiši še v tabelo na listu
	+ izračunaj razmerje med tlakom in temperaturo za vse pare izmerkov in ugotovi, ali je razmerje konstantno v okviru napake meritve
	+ nariši graf tlaka v odvisnoti od temperature $p=p(T)$
1. Izmerki in rezultati:

|  |  |  |  |
| --- | --- | --- | --- |
|  | $T$[K] | $p$ [kPa] | $p/T$ [kPa/K] |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |

Katera funkcija se najbolje prilega točkam v grafu?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## **ISOTHERMIC AND ISOCHORIC GAS CHANGES**

Check the validity of Boyle’s Law (of isothermal gas change) and Graham’s law (of isochoric gas change) for air.

Materials:

* + syringe
	+ pressure sensor
	+ Vernier computer interface
	+ thermometer
	+ calorimeter with heater

BOYLE’S LAW

1. Instructions:

* + Ensure that the volume of air in the syringe is approximately 10 ml.
	+ Gently screw the syringe onto the pressure sensor. Do not break the nozzle on the sensor.
	+ Connect the sensor to the computer interface.
	+ Change the measurement mode on the interface (*Events with Entry*).
	+ Commence measuring (Green arrow).
	+ Input the measurement into the interface (Keep button) and notate the values for pressure and volume in the table on the worksheet.
	+ Slowly decrease the volume by 1 ml and input the measurement.
	+ Continue decreasing the volume by 1 ml to a value of 5 ml; input the pressure and volume measurements after each subsequent decrease.
	+ Let the syringe return to a value of 10 ml; now increase the volume by 1 ml to a value of 15 ml notating pressure and volume measurements after each increase.
	+ Calculate the product of the pressure and volume for each pair of measurements and determine whether the value of the constant is within the limits of allowable measurement error.
	+ Use the analysis function on the interface to find the best fit for the curve (*Analyse -> Curve Fit -> Power*); on the worksheet, plot the p-V graph.
1. Measurements and results:

|  |  |  |  |
| --- | --- | --- | --- |
|  | $V$[ml] | $p$ [kPa] | $pV$ [ml kPa] |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |

Which function is the best fit for the points of the graph?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

GRAHAM’S LAW

1. Instructions:

* + Connect the sensor to the computer interface and change the measurement mode on the interface (*Events with Entry*).
	+ Attach plug to pressure sensor and close the flask.
	+ Pour water into the calorimeter; in the water place the flask, heater and thermometer.
	+ Wait a few minutes to establish thermal equilibrium between the water and air.
	+ Commence measuring (Green arrow).
	+ Read the starting temperature and measurements and input into the interface (Keep button).
	+ Connect the heater.
	+ Wait for the temperature to rise 2 degrees and re-enter the measurements.
	+ Perform at least five measurements.
	+ Use the analysis function on the interface to find the best fit for the curve (*Analyse -> Curve Fit*).
	+ Notate the values of the pressure and temperature in the table on the worksheet.
	+ Calculate the ratio between pressure and temperature for all measured pairs and determine whether the value of the constant is within the limits of allowable measurement error.
	+ Plot a graph of pressure versus time, $p=p(T)$.
1. Measurements and results:

|  |  |  |  |
| --- | --- | --- | --- |
|  | $T$[K] | $p$ [kPa] | $p/T$ [kPa/K] |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |
| 6 |  |  |  |

Which function best-represents the points on the graph?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## **POLNJENJE IN PRAZNJENJE KONDENZATORJA**

Izmeri čas polnjenja in praznjenja kondenzatorja.

Pripomočki:

* + upornik
	+ elektrolitski kondenzator
	+ Vernier vmesnik (merilnik) z veznimi vrvicami
	+ usmernik (6 V)
	+ vezne žice

Slika 2: Praznjenje kondenzatorja

Slika 1: Polnjenje kondenzatorja

+

V

V

+

+

POLNJENJE KONDENZATORJA

1. Navodilo:

* + sestavi vezje, kot je na shemi (slika 1); bodi pozoren na polariteto kondenzatorja;
	+ zapiši podatke o velikosti upornika, kondenzatorja in napetosti, s katero polniš kondenzator, na list;
	+ **preden vezje priključiš na napetost, pokliči učitelja!**
	+ napetost boš meril z Vernerjevim vmesnikom, zato na mesto voltmetra vzporedno h kondenzatorju poveži vmesnik;
	+ na vmesniku nastavi čas merjenja na 60 s;
	+ prepričaj se, da je kondenzator prazen; prični z meritvijo in skleni stikalo, da se kondenzator polni preko upornika;
	+ po končani meritvi v tabelo prepiši napetost na kondenzatorju pri desetih različnih časih
	+ s pomočjo izmerkov prepriši graf napetosti na kondenzatorju v odvisnosti od časa $U=U(t)$ na list;
1. Izmerki :

|  |  |  |
| --- | --- | --- |
| Kondenzator: | Upornik: | Napetost polnjenja: |
| $C $= \_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $R$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $U\_{0}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

|  |  |  |
| --- | --- | --- |
|  | $U$ [V] | $t$ [s] |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

3. Rezultat:

Za polnjenje kondenzatorja velja enačba: $U\left(t\right)=U\_{0}(1-e^{-\frac{t}{τ}})$. Vrednost časovne konstante $τ$ je odvisna od kapacitete kondenzatorja in upora upornika, skozi katerega se kondenzator polni. Za $τ$ velja, da je enaka produktu kapacitete in upora: $τ=CR$. Preveri veljavnost te zveze.

Po preteku časa $t$, ki je enak časovni konstanti $τ$, je napetost na kondenzatorju enaka $U=U\_{0}(1-\frac{1}{e})$, torej približno $\frac{2}{3}U\_{0}$. Iz grafa odčitaj vrednost za $τ$ in preveri, ali velja, da je $τ=CR$.

$τ$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

$CR$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ali velja, da je $τ=CR$?

DA NE

Graf napetosti v odvisnosti od časa $U=U(t)$ je:

* linearna funkcija
* kvadratna funkcija
* eksponentna funkcija
* konstanta

Torej: pri polnjenju kondrnzatorja se napetost na kondenzatorju spreminja kot \_\_\_\_\_\_\_\_\_\_ funkcija časa.

PRAZNJENJE KONDENZATORJA

1. Navodilo:

* + sestavi vezje, kot je na shemi (slika 2); bodi pozoren na polariteto kondenzatorja;
	+ zapiši podatke o velikosti upornika, kondenzatorja in napetosti, s katero si napolnil kondenzator, na list;
	+ **preden priključiš kondenzator na napetost, pokliči učitelja!**
	+ napetost boš meril z Vernerjevim vmesnikom, zato na mesto voltmetra vzporedno h kondenzatorju poveži vmesnik;
	+ na vmesniku nastavi čas merjenja na 60 s;
	+ napolni kondenzator (6 V);
	+ prični z meritvijo in skleni stikalo, da se kondenzator prazni preko upornika;
	+ po končani meritvi v tabelo prepiši napetost na kondenzatorju pri desetih različnih časih
	+ s pomočjo izmerkov prepriši graf napetosti na kondenzatorju v odvisnosti od časa $U=U(t)$ na list;
1. Izmerki :

|  |  |  |
| --- | --- | --- |
| Kondenzator: | Upornik: | Začetna napetost: |
| $C $= \_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $R$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $U\_{0}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

|  |  |  |
| --- | --- | --- |
|  | $U$ [V] | $t$ [s] |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

3. Rezultat:

Za praznjenje kondenzatorja velja enačba: $U\left(t\right)=U\_{0}e^{-\frac{t}{τ}}$. Vrednost časovne konstante $τ$ je enaka kot prej in je odvisna od kapacitete kondenzatorja in upora upornika, skozi katerega se kondenzator prazni. Velja: $τ=CR$.

Po preteku časa $t$, ki je enak časovni konstanti $τ$, je napetost na kondenzatorju enaka $U=\frac{1}{e}U\_{0})$, torej približno $\frac{1}{3}U\_{0}$. Iz grafa odčitaj vrednost za $τ$ in preveri, ali tudi za praznjenje velja, da je $τ=CR$.

$τ$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

$CR$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ali velja, da je $τ=CR$?

DA NE

Graf napetosti v odvisnosti od časa $U=U(t)$ pri praznjenju kondenzatorja je:

* linearna funkcija
* kvadratna funkcija
* eksponentna funkcija
* konstanta

Torej: pri praznjenju kondrnzatorja se napetost na kondenzatorju spreminja kot \_\_\_\_\_\_\_\_\_\_ funkcija časa.

## **CHARGING AND DISCHARGING CAPACITORS**

Measure the time a capacitor takes to charge and discharge.

Accessories:

* + resistor
	+ electrolytic capacitor
	+ Vernier interface with voltage sensor
	+ 6V rectifier
	+ connecting wires

Image 2: Discharging a capacitor

Image 1: Charging a capacitor

+

V

V

+

+

CHARGING A CAPACITOR

1. Instructions:

* + connect the circuit as per the circuit diagram (image 1); pay attention to the polarity of the capacitor;
	+ notate the size of the resistor, capacitor and voltage with which you charge the capacitor;
	+ **Before you connect the capacitor to the voltage, call the teacher!**
	+ you will measure the voltage with the Vernier interface, therefore you need to connect the interface in parallel with the capacitor;
	+ the interface needs to remain connected for 60 s to obtain sufficient measurements;
	+ convince yourself that the capacitor is discharged; commence measuring and resolve the switch so that the capacitor charges through the resistor;
	+ after the measurement is completed, notate the capacitor’s voltage at 10 different times;
	+ with the assistance of your measurements, draw the graph of voltage as a function of time $U=U(t)$;
1. Measurements:

|  |  |  |
| --- | --- | --- |
| Capacitor: | Resistor: | Charging voltage: |
| $C $= \_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $R$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $U\_{0}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

|  |  |  |
| --- | --- | --- |
|  | $U$ [V] | $t$ [s] |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

3. Results:

When charging capacitors the equation $U\left(t\right)=U\_{0}(1-e^{-\frac{t}{τ}})$ applies. The value of the time constant $τ$ is dependent on the capacitance of the capacitor and the resistance of the resistor through which the capacitor charges. $τ$ is calculated as the product of capacitance and resistance: $τ=CR$. Verify the validity of this relation.

After time $t$, which is equal to the time constant $τ$, the voltage of the capacitor is equal to $U=U\_{0}(1-\frac{1}{e})$, approximately $\frac{2}{3}U\_{0}$. From the graph, read the values for $τ$ and verify whether $τ=CR$.

$τ$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

$CR$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Does $τ=CR$?

YES NO

The graph of voltage as a function of time $U=U(t)$ is:

* a linear function
* a quadratic function
* an exponential function
* constant

So, when charging a capacitor the voltage across the capacitor varies as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ function of time.

DISCHARGING CAPACITOR

1. Instructions:

* + connect the circuit as per the circuit diagram (image 2); pay attention to the polarity of the capacitor;
	+ notate the size of the resistor, capacitor and voltage with which you charge the capacitor;
	+ **Before you connect the capacitor to the voltage, call the teacher!**
	+ you will measure the voltage with the Vernier interface, therefore you need to connect the interface in parallel with the capacitor;
	+ the interface needs to remain connected for 60 s to obtain sufficient measurements;
	+ charge the capacitor using the 6 V rectifier;
	+ commence measuring and resolve the switch so that the capacitor discharges through the resistor;
	+ after the measurement is completed, notate the capacitor’s voltage at 10 different times;
	+ with the assistance of your measurements, draw the graph of voltage as a function of time $U=U(t)$;
1. Measurements:

|  |  |  |
| --- | --- | --- |
| Capacitance: | Resistance: | Starting voltage: |
| $C $= \_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $R$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | $U\_{0}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

|  |  |  |
| --- | --- | --- |
|  | $U$ [V] | $t$ [s] |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |

3. Results:

For discharging capacitors the equation $U\left(t\right)=U\_{0}e^{-\frac{t}{τ}}$. applies. The value of the time constant $τ$ is as before dependent on the capacitance of the capacitor and the resistance of the resistor through which the capacitor discharges. $τ=CR$.

After time $t$, which is equal to the time constant $τ$, the voltage of the capacitor is equal to $U=\frac{1}{e}U\_{0}),$ approximately $\frac{1}{3}U\_{0}$. From the graph, read the values for $τ$ and verify whether $τ=CR$.

$τ$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

$CR$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Does $τ=CR$?

YES NO

The graph of voltage as a function of time $U=U(t)$ when discharging a capacitor is:

* a linear function
* a quadratic function
* an exponential function
* constant

So, when discharging a capacitor the voltage across the capacitor varies as a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ function of time.

## **SOLARNA KONSTANTA**

Izmeri solarno konstanto (gostoto svetlobnega toka s Sonca na površini Zemlje).

Pripomočki:

* + lonček (črne barve)
	+ termometer
	+ štoparica
	+ meter
	+ kljunasto merilo

VPADNI KOT SONČNIH ŽARKOV

1. Navodilo:
* v zemljo zapiči palico;
* z nihalko preveri, ali res stoji navpično;
* izmeri višino palice, dolžino sence in izračunaj vpadni kot $α$;

$$y$$

$$α$$

$$x$$

1. Izmerki in izračuni:

Višina palice in dolžina sence:

$y$ = \_\_\_\_\_\_\_\_\_\_\_\_\_

$x$ = \_\_\_\_\_\_\_\_\_\_\_\_\_

$α$ = \_\_\_\_\_\_\_\_\_\_\_\_\_

SOLARNA KONSTANTA

1. Navodilo:

* + v lonček nalij skoraj do vrha znano maso vode in lonček zapri s pokrovčkom
	+ skozi pokrovček v vodo vstavi termometer; nekoliko počakaj in zapiši začetno temperaturo vode
	+ lonček postavi na Sonce (lonček naj stoji pokonci) in prični meriti čas,
	+ medtem ko čakaš, da se voda segreje, izmeri vpadni kot sončnih žarkov;
	+ odčitaj temperaturo, do katere se je voda segrela in čas segrevanja; podatke zapiši;
	+ vodo izlij iz lončka (če je še nisi stehtal, jo zdaj, preden vliješ vodo stran!);
	+ izmeri višino in premer lončka;
	+ izračunaj solarno konstanto;
1. Izmerki in izračun:

Solarna kosntanta $j\_{0}$ je gostota svetlobnega toka s Sonca na površini Zemlje. Gostota svetlobnega toka, ki pada na lonček, segreva vodo v lonču. Da se je masa vode $m$ segrela za $∆$T, je prejela toploto $Q=mc∆T$ ($c$ = 4200 J/kgK).

V času $t$ prejme lonček toploto: $Q=jSt$, pri čemer je $j$ osvetljenost lončka, $S$efektivna površina valja, ki prejema toploto, in $t$ čas.

Na lonček pada svetlobni tok $j\_{0}$ , vendar lonček segreva samo konponenta svetlobnega toka $j$ (osvetljenost), ki je pravokotna na plašč valja: $j=j\_{0}cosφ$.

Osvetljena je samo polovica plašča lončka. Poleg tega pada svetloba pod pravim kotom na plašč samo na sredini, proti robovoma je osvetljenost vedno manjša. Izkaže se, da je efektivna površina, ki absorbira sončno svetlobo, enaka osnovnemu preseku valja: $S=2rh$, pri čemer je $2r$ premer valja in $h$ višina valja.

$$j\_{0}$$

Premer lončka:

$2r$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

$$φ$$

Višina lončka:

$$j$$

$h$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Efektivna površina:

$S$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Voda:

Osvetljenost:

$$Q\_{od}=Q\_{sp}$$

$$jSt=mc∆T$$

$$j=…$$

Solarna konstanta:

$$j=j\_{0}cosφ$$

$$j\_{0}=..$$

$m$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{Z}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{k}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Čas segrevanja:

$t$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Rezultat:

Osvetljenost lončka:

$j$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Solarna konstanta:

$j\_{0}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

## **SOLAR CONSTANT**

Measure the solar constant (density of luminous flux of the Sun on the Earth’s surface).

Materials:

* + cup (small)
	+ thermometer
	+ stop watch
	+ metre rule
	+ Vernier calliper

ANGLE OF INCIDENCE OF SUNRAY

Instructions:

* Stick the rod in the ground in an upright position;
* Verify with a pendulum whether the rod is standing perpendicularly;
* Measure the height of the rod, the length of its shadow and calculate the sunray’s angle of incidence $α$;

$$y$$

$$α$$

$$x$$

1. Measurements and calculations:

Height of rod and length of shadow:

$y$ = \_\_\_\_\_\_\_\_\_\_\_\_\_

$x$ = \_\_\_\_\_\_\_\_\_\_\_\_\_

$α$ = \_\_\_\_\_\_\_\_\_\_\_\_\_

SOLAR CONSTANT

1. Instructions:

* + Fill the cup almost to the rim with water of a known mass and close the lid;
	+ Insert the thermometer through the lid, wait a few moments and write down the water’s initial temperature;
	+ Place the cup in an upright position and start measuring the time;
	+ Whilst waiting for the water to heat up, measure the angle of incidence of the sunray;
	+ Read the temperature at which the water heats up and the time it takes to heat up; record this data;
	+ Empty the water from the cup (if you haven’t weighed it yet, do this now before you throw the water away!);
	+ Measure the height and diameter of the cup;
	+ Calculate the solar constant;
1. Measurements and calculations:

The solar constant $j\_{0}$ is the density of luminous flux on the Earth’s surface. The density of luminous flux, which falls on the cup, heats the water in the cup. That is, water of mass $m$ is heated by $∆$T, and gains heat $Q=mc∆T$ ($c$ = 4200 J/kgK).

In time $t$, the cup gains heat $Q=jSt$, where $j$ is the illumination of the cup, $S$ is the effective surface area of the cylinder and $t$ is time.

The amount of sunlight which falls on the cup is $j\_{0}$; however the cup is only heated by a component of sunlight $j$ (illumination), which is perpendicular to the cylinder’s curved surface: $j=j\_{0}cosφ$.

Only half of the cup’s curved surface area is illuminated. In addition to this, the sunlight only falls at right angles in the middle of the curved surface, whereas towards the edges the illumination is always less. It turns out that the effective surface area upon which sunlight is absorbed is the same as a cylinder’s curved surface area: $S=2rh$, where $2r$ is the cylinder’s diameter and $h$ is the cylinder’s height.

$$j\_{0}$$

Diameter of cup:

$2r$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

$$φ$$

Height of cup:

$$j$$

$h$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Effective surface area:

$S$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Water:

Illumination:

$$Q\_{od}=Q\_{sp}$$

$$jSt=mc∆T$$

$$j=…$$

Solar constant:

$$j=j\_{0}cosφ$$

$$j\_{0}=..$$

$m$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{Z}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{k}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Heating time:

$t$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Result:

Illumination of cup:

$j$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Solar constant:

$j\_{0}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

## **MERJENJE SPECIFIČNE TOPLOTE KOVINE**

Izmeri toplotno kapaciteto kalorimetra in specifično toploto kovine.

Pripomočki:

* + kalorimeter
	+ termometer
	+ tehtnica
	+ kovinsko telo (segrete v vreli vodi)

TOPLOTNA KAPACITETA KALORIMETRA

1. Navodilo:

* + v kalorimeter do ¾ nalij hladno vodo;
	+ nekoliko počakaj, da se vzpostavi termično ravnovesje in izmeri začetno temperaturo $T\_{1}$ hladne vode; to je tudi začetna temperatura kalorimetra;
	+ v čašo nalij znano maso tople vode in izmeri njeno temperaturo;
	+ hladno vodo zlij iz kalorimetra in vanj takoj vlij toplo vodo znane temperature $T\_{2}$;
	+ počakaj, da se vzpostavi termično ravnovesje (nekaj minut) in izmeri končno temperaturo $T\_{k}$ vode in kalorimetra;
	+ izračunaj toplotno kapaciteto kalorimetra (izhajaj iz tega, da je toplota, ki jo topla voda odda, enaka toploti, ki jo kalorimeter prejme);
1. Izmerki in izračun:

Kalorimeter:

$T\_{1}$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Topla voda:

$m$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{2}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Končna temperatura:

$T\_{k}$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Rezultat:

Toplotna kapaciteta kalorimetra:

$C$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

SPECIFIČNA TOPLOTA NEZNANE KOVINE

1. Navodilo:

* + v kalorimeter do ¾ nalij znano maso hladne vode $m\_{1}$;
	+ nekoliko počakaj, da se vzpostavi termično ravnotežje in izmeri začetno temperaturo $T\_{1}$ hladne vode; to je tudi začetna temperatura kalorimetra;
	+ v loncu na kuhalniku v vreli vodi segrej kos kovine, ki mu boš izmeril specifično toploto; temperatura vrele vode $T\_{2}$ (izmeri jo!) je začetna temperatura kovine;
	+ kovino čimhitreje premakni iz vrele vode v kalorimeter s hladno vodo;
	+ kalorimeter takoj pokrij s pokrovom in v vodo v kalorimetru vstavi termometer;
	+ spremljaj temperaturo; nekoliko počakaj, da se vzpostavi termično ravnovesje (nekaj minut) in izmeri končno temperaturo $T\_{k}$ vode in kalorimetra;
	+ izračunaj specifično toploto kovine (izhajaj iz tega, da je toplota, ki jo kovina odda, enaka toploti, ki jo voda in kalorimeter prejmeta); pri izračunu upoštevaj tudi toplotno kapaciteto kalorimetra;
1. Izmerki in izračun:

Kalorimeter:

$C$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{1}$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hladna voda:

$m\_{1}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{1}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Kovina:

$m\_{2}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{2}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Končna temperatura:

$T\_{k}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Rezultat:

Specifična toplota kovine:

$c$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## **MEASURING THE SPECIFIC HEAT OF METALS**

Measure the heat capacity of a calorimeter and the specific heat of metals.

Materials:

* + calorimeter
	+ thermometer
	+ scales
	+ metal body (heated in boiling water)

HEAT CAPACITY OF A CALORIMETER

1. Instructions:

* + Fill the calorimeter with cold water until it is ¾ filled;
	+ Wait until thermal equilibrium is established and measure the initial temperature $T\_{1}$ of the cold water; this is also the initial temperature of the calorimeter;
	+ Fill a measuring jug with warm water (of known mass) and measure its temperature;
	+ Empty the cold water from the calorimeter and immediately fill it with the warm water of known temperature $T\_{2}$;
	+ Wait until the thermal equilibrium is established (a few minutes) and measure the final temperature $T\_{k}$ of the water in the calorimeter;
	+ Calculate the heat capacity of the calorimeter (derived from the fact that the heat which the water loses is the same heat which is gained by the calorimeter);
1. Measurements and calculations:

Calorimeter:

$T\_{1}$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Warm water:

$m$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{2}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Final temperature:

$T\_{k}$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Results:

Heat capacity of calorimeter:

$C$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

SPECIFIC HEAT OF AN UNKNOWN METAL

1. Instructions:

* + Fill the calorimeter with cold water of a known mass $m\_{1}$ until it is ¾ filled;
	+ Wait until thermal equilibrium is established and measure the initial temperature $T\_{1}$ of the cold water; this is also the initial temperature of the calorimeter;
	+ In a pot of boiling water on a heat source, warm a piece of metal for which you will measure its specific heat; the temperature of the boiling water $T\_{2}$ (measure it!) is the initial temperature for the metal;
	+ After a short time, remove the metal piece from the boiling water and place it into a cold water-filled calorimeter;
	+ Immediately cover the calorimeter with a lid and place a thermometer into the water;
	+ Monitor the temperature change; wait until thermal equilibrium is established (a few minutes) and measure the final temperature $T\_{k}$ of the water in the calorimeter;
	+ Calculate the specific heat of the metal (derived from the fact that the heat which the metal loses is the same heat which is gained by the calorimeter and water); when calculating take into account the specific capacity of the calorimeter;
1. Measurements and calculations:

Calorimeter:

$C$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{1}$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Cold water:

$m\_{1}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{1}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Metal:

$m\_{2}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

$T\_{2}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Final temperature:

$T\_{k}$ = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Result:

Specific heat of metal:

$c$= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_