

Name _____ Surname _____ Date ____/____/____

Midterm test: Measurement

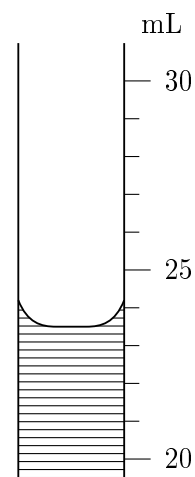
Duration: 70 minutes. **Total:** 100 points. A calculator is allowed. Write your answers on this sheet. Show your working in every calculation, and give final answers with the correct unit and the correct number of significant figures. A data sheet is on the last page.

Safety net. The questions marked ⚬ are worth 60 points out of 100, that is 60%: if you answer all of them correctly, you pass.

Exercise 1 — Reading instruments

10 points

The figure shows part of the scale of a measuring cylinder. The water level is shown.



- (a) ⚬ What is the value of one division of the scale? [2 p.]

Answer: _____

- (b) ⚬ Read the volume of water, in mL. [3 p.]

Answer: _____

- (c) ⚬ What is the uncertainty of one reading on this cylinder? [2 p.]

Answer: _____

- (d) ⚬ A digital balance shows 94.0 g. What is the uncertainty of this reading? [2 p.]

Answer: _____

- (e) ⚬ To read the level correctly, your eye should be: [1 p.]

☐ above the water ☐ level with the bottom of the curved surface ☐ below the water

Exercise 2 — Random or systematic error?

10 points

- ⚬ For each situation, tick the type of error. [2 p.] each

	Random	Systematic
(a) A student starts a stopwatch sometimes a little early and sometimes a little late.	☐	☐
(b) A balance reads 0.2 g with nothing on the pan.	☐	☐
(c) A paper cone falls. The wind changes in a random way, so the cone sometimes falls faster and sometimes slower.	☐	☐
(d) A student always reads a measuring cylinder with her eye above the level of the water.	☐	☐

- (e) ⚬ Repeating a measurement and taking the mean reduces: [2 p.]

☐ random errors ☐ systematic errors ☐ both ☐ neither

Exercise 3 — True or false?	10 points																		
⚬ Tick True or False. No explanation is needed. [2 p.] each <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 80%;"></th> <th style="width: 10%; text-align: center;">True</th> <th style="width: 10%; text-align: center;">False</th> </tr> </thead> <tbody> <tr> <td>(a) You press start and stop on a stopwatch with your finger. The stopwatch shows 0.01 s, so your time is correct to ± 0.01 s.</td> <td style="text-align: center;">☐</td> <td style="text-align: center;">☐</td> </tr> <tr> <td>(b) If you start and stop a stopwatch with the same delay, the time you read is still correct.</td> <td style="text-align: center;">☐</td> <td style="text-align: center;">☐</td> </tr> <tr> <td>(c) Taking the mean of many readings removes a zero error.</td> <td style="text-align: center;">☐</td> <td style="text-align: center;">☐</td> </tr> <tr> <td>(d) The range of a set of readings is the largest value minus the smallest value.</td> <td style="text-align: center;">☐</td> <td style="text-align: center;">☐</td> </tr> <tr> <td>(e) Readings that are close together but all far from the true value are precise but not accurate.</td> <td style="text-align: center;">☐</td> <td style="text-align: center;">☐</td> </tr> </tbody> </table>			True	False	(a) You press start and stop on a stopwatch with your finger. The stopwatch shows 0.01 s, so your time is correct to ± 0.01 s.	☐	☐	(b) If you start and stop a stopwatch with the same delay, the time you read is still correct.	☐	☐	(c) Taking the mean of many readings removes a zero error.	☐	☐	(d) The range of a set of readings is the largest value minus the smallest value.	☐	☐	(e) Readings that are close together but all far from the true value are precise but not accurate.	☐	☐
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Exercise 4 — Conversions, standard form, rounding	10 points																		
⚬ Answer each question. [2 p.] each <table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 60%;">(a) Convert 450 mg to g.</td> <td style="width: 40%;">Answer: _____</td> </tr> <tr> <td>(b) Convert 54 km/h to m/s.</td> <td>Answer: _____</td> </tr> <tr> <td>(c) Write 7200 000 m in standard form.</td> <td>Answer: _____</td> </tr> <tr> <td>(d) Write 0.000036 s in standard form.</td> <td>Answer: _____</td> </tr> <tr> <td>(e) Round 3.9871 kg to 2 significant figures.</td> <td>Answer: _____</td> </tr> </tbody> </table>		(a) Convert 450 mg to g.	Answer: _____	(b) Convert 54 km/h to m/s.	Answer: _____	(c) Write 7200 000 m in standard form.	Answer: _____	(d) Write 0.000036 s in standard form.	Answer: _____	(e) Round 3.9871 kg to 2 significant figures.	Answer: _____								
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Exercise 5 — Quantities and units	10 points																		
(a) ⚬ The SI base unit of mass is: [2 p.] ☐ A gram ☐ B kilogram ☐ C milligram ☐ D newton (b) ⚬ Which of these is a <i>derived</i> quantity? [2 p.] ☐ A length ☐ B mass ☐ C time ☐ D density (c) ⚬ The unit of density is: [2 p.] ☐ A m^3/kg ☐ B kg m^3 ☐ C kg/m^3 ☐ D N/m^2 (d) ⚬ 5 km is equal to: [2 p.] ☐ A 0.005 m ☐ B 50 m ☐ C 5000 m ☐ D 500 000 m (e) ⚬ True or false? “38.4×10^4 m is written in standard form.” [2 p.] ☐ True ☐ False																			
Exercise 6 — Significant figures	10 points																		
⚬ Write the number of significant figures of each measurement. [2 p.] each <table style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="width: 33%;">(a) 0.0072 m _____</td> <td style="width: 33%;">(b) 207 s _____</td> <td style="width: 33%;">(c) 5.00 kg _____</td> </tr> <tr> <td>(d) 0.03040 m _____</td> <td>(e) 2.80×10^3 m _____</td> <td></td> </tr> </tbody> </table>		(a) 0.0072 m _____	(b) 207 s _____	(c) 5.00 kg _____	(d) 0.03040 m _____	(e) 2.80×10^3 m _____													
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Exercise 7 — Which container?**10 points**

A student wants the density of a small pebble of mass $m = 38.2 \pm 0.1$ g. She measures its volume by water displacement, using two different containers.

	Range	One division	V_1	V_2
Cylinder	100 mL	1 mL	50.0 mL	65.0 mL
Beaker	250 mL	25 mL	150 mL	175 mL

- (a) Write the uncertainty of one reading for each container. **[2 p.]**

Cylinder: _____ Beaker: _____

- (b) For each container calculate $V = V_2 - V_1$, its uncertainty and its relative uncertainty. **[3 p.]**

- (c) Which container should she use? Explain in one sentence.

_____ **[1 p.]**

- (d) Using the better container, calculate the density and write the final result as $\rho \pm$ uncertainty, in g/cm³. **[3 p.]**

- (e) A classmate says: “It must be granite, because 2.6 is in the table.” Is he right? Use the rock table on the data sheet.

_____ **[1 p.]**

Exercise 8 — Two students, one swinging apple**10 points**

An apple swings on a string. The true time of one complete swing is 2.50 s. Two students time it five times with a stopwatch.

Student X (s)	2.80	2.78	2.83	2.79	2.81
Student Y (s)	2.35	2.62	2.48	2.71	2.40

(a) Calculate the mean of each student's readings, to 3 significant figures. **[2 p.]**

(b) Calculate the range of each student's readings. **[2 p.]**

(c) Which student has the larger random error? Which student has a systematic error, and how large is it?

[2 p.]

(d) Student X says: "If I take 100 more readings, my mean will get to 2.50 s." Is he right? Explain.

[2 p.]

(e) Suppose you did not know the true value. Could you tell from X's readings alone that X has a systematic error? Explain.

[2 p.]

Exercise 9 — A rolling ball**10 points**

A student times a ball rolling down a ramp six times with a stopwatch.

Reading	1	2	3	4	5	6
Time / s	1.62	1.58	1.64	1.60	1.55	1.61

- (a) Calculate the mean time. Give your answer to 3 significant figures. **[3 p.]**
- (b) Calculate the range of the readings. **[2 p.]**
- (c) Suggest one reason why the readings are not all equal.
_____ **[2 p.]**
- (d) The true time of the ball is 1.60 s. Another student starts the stopwatch 0.30 s late and stops it exactly on time. What time does the stopwatch show? _____ **[1 p.]**
- (e) This student does the same every time. Is his error random or systematic? Explain in one sentence.
_____ **[2 p.]**

Exercise 10 — Density of a metal cube**10 points**

A student measures a metal cube. The side is $l = 3.0 \pm 0.1$ cm and the mass is $m = 213.0 \pm 0.1$ g. Use the rules on the data sheet.

- (a) Calculate the relative uncertainty of l , in %. _____ **[1 p.]**
- (b) Calculate the volume $V = l^3$ and its relative uncertainty. **[2 p.]**
 $V =$ _____ relative uncertainty = _____
- (c) Calculate the absolute uncertainty of V . _____ **[1 p.]**
- (d) Calculate the relative uncertainty of m , in %. _____ **[1 p.]**
- (e) Calculate the density $\rho = m/V$ and write the final result as $\rho \pm$ uncertainty, in g/cm³. **[3 p.]**
- (f) Which materials in the table on the data sheet are compatible with your result? Can you decide which metal the cube is made of? Explain in one sentence.

_____ **[2 p.]**

Data sheet

Prefixes. $1 \text{ km} = 10^3 \text{ m}$ $1 \text{ mg} = 10^{-3} \text{ g}$ $1 \mu\text{s} = 10^{-6} \text{ s}$ $1 \text{ nm} = 10^{-9} \text{ m}$

Standard form. $a \times 10^n$ with $1 \leq a < 10$ and n an integer.

Other. $1 \text{ h} = 3600 \text{ s}$ $1 \text{ mL} = 1 \text{ cm}^3$ density $\rho = \frac{m}{V}$

Rules of uncertainty

1. Analogue instrument: the uncertainty of one reading is half a division.
2. Digital instrument: the uncertainty of one reading is the last digit shown.
3. Difference of two readings ($V_2 - V_1$): the uncertainties add.
4. Relative uncertainty = $\frac{\text{uncertainty}}{\text{value}} \times 100\%$.
5. Product or quotient: the relative uncertainties add. For a cube, $V = l^3$, so the relative uncertainty of V is 3 times that of l .
6. Absolute uncertainty = relative uncertainty $\times$ value. Round the uncertainty to one significant figure.
7. Read a liquid level at the bottom of the curved surface, with your eye level with it.

Densities (g/cm^3 , approximate)

Material	ρ	Rock	ρ
Water	1.00	Sandstone	2.2–2.8
Aluminium	2.7	Limestone	2.3–2.7
Steel	7.8	Granite	2.6–2.7
Brass	8.5	Marble	2.6–2.8
Copper	8.9	Slate	2.7–2.8
		Basalt	2.8–3.0