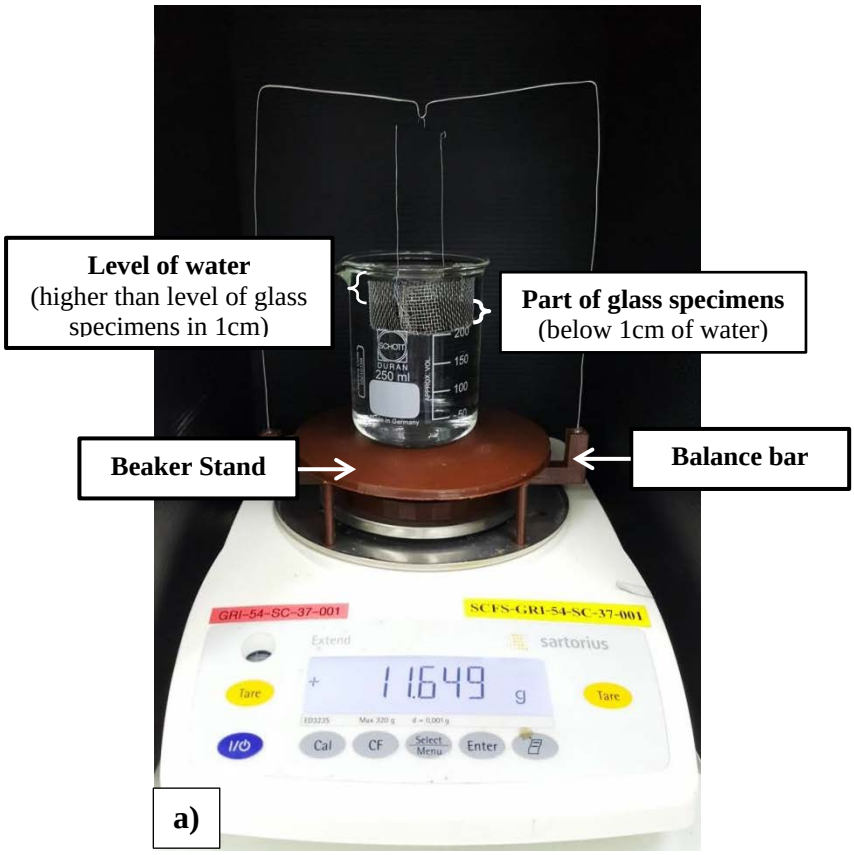
Instruction Manuals of
The density determination kit based on the buoyancy method

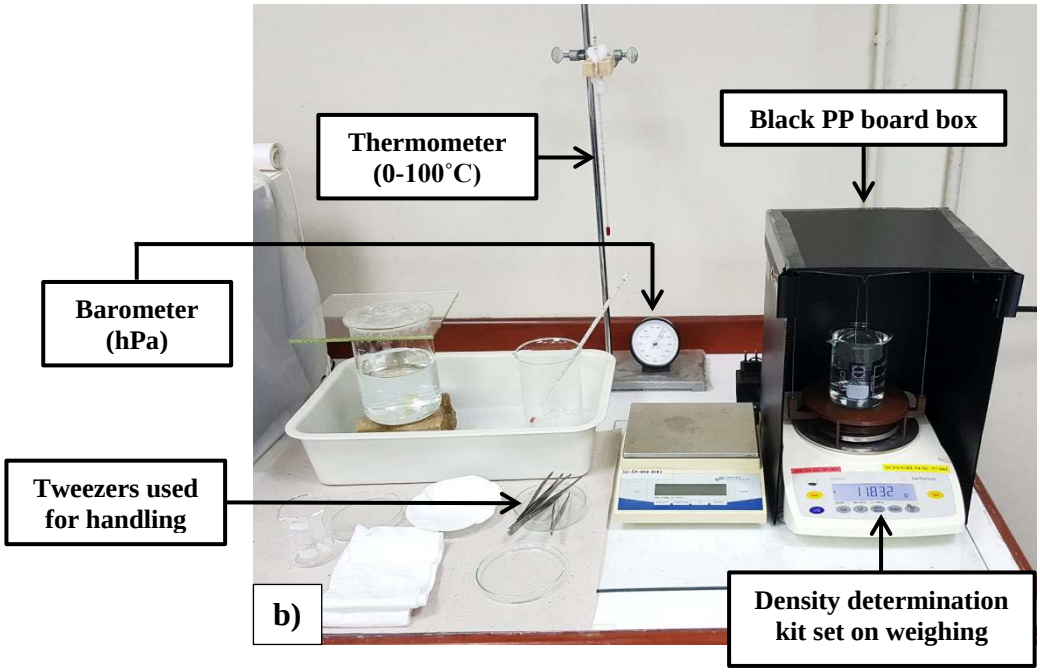
Purpose

This document is the guideline for use of the density determination kit based on the buoyancy method. It has designed to provide "How to use it for determining the glass density?". It concludes the experimental instruments, experimental setup, experimental procedure, and calculation of density values.

Experimental instruments and setup

1. *Water preparation*:
    - add 0.1mL of surfactant in 200mL of boiled DI water
    - use it within 24 hours
2. *Specimen preparation*:
    - use at least 20g of cleaned and dried glass specimens





Experimental procedure

1. Weight the balance bar with empty basket in air and tare to zero
2. Put 20g of glass specimens in the basket, weight them in the air (W_A in g), and put them out from the basket
3. Weight the balance bar with empty basket in water (beaker of DI water) and tare to zero
4. Put one by one of 20g of glass specimens in the basket, weight them in water (W_W in g), and put them out from the basket
5. Let the glass specimens dry
6. Repeat all steps for 3 times

Additional Note:

- Read the laboratory air temperature (T_A in ˚C) and the barometric pressure (P_A in hPa) for air density determination (ρ_A)
- Read the water temperature (T_W in ˚C) of DI water in beaker for water density determination (ρ_W)
- Measure density of glass specimens (ρ_S) from

$$\rho_S = \frac{W_A}{W_A - W_W} \times (\rho_W - \rho_A) + \rho_A$$

- Determine the water density (ρ_W) from Table1 as follow

Table1: Density of Air-Free Water (g/cm^3) from ASTM Standard test method (C693-93).

Temperature of water (T_W/ ˚C)		20	21	22	23	24	25
The first decimal of temperature	0	0.9982	0.99799	0.99777	0.99754	0.9973	0.99705
	0.1	0.99818	0.99797	0.99775	0.99752	0.99727	0.99702
	0.2	0.99816	0.99795	0.99773	0.99749	0.99725	0.997
	0.3	0.99814	0.99793	0.9977	0.99747	0.99722	0.99697
	0.4	0.99812	0.99791	0.99768	0.99744	0.9972	0.99694
	0.5	0.9981	0.99788	0.99766	0.99742	0.99717	0.99692
	0.6	0.99808	0.99786	0.99763	0.9974	0.99715	0.99689
	0.7	0.99806	0.99784	0.99761	0.99737	0.99712	0.99687
	0.8	0.99804	0.99782	0.99759	0.99735	0.9971	0.99684
	0.9	0.99801	0.99779	0.99756	0.99732	0.99707	0.99681

Temperature of water (T_W/ ˚C)		26	27	28	29	30
The first decimal of temperature	0	0.99679	0.99652	0.99624	0.99595	0.99565
	0.1	0.99676	0.99649	0.99621	0.99592	0.99562
	0.2	0.99673	0.99646	0.99618	0.99589	0.99559
	0.3	0.99671	0.99643	0.99615	0.99586	0.99556
	0.4	0.99668	0.9964	0.99612	0.99583	0.99553
	0.5	0.99665	0.99638	0.99609	0.9958	0.9955
	0.6	0.99662	0.99635	0.99606	0.99577	0.99547
	0.7	0.9966	0.99632	0.99603	0.99574	0.99543
	0.8	0.99657	0.99629	0.996	0.99571	0.9954
	0.9	0.99654	0.99626	0.99598	0.99568	0.99537

- Determine the air density (ρ_A) from

$$\rho_A = \frac{0.0012932}{1 + (0.0036728 \times T_A)} \times \frac{P_A}{1013.25}$$

Laboratory recording sheet

Sample	**Round** (Times)	**Temp of air** (T_A , ˚C)	**Pressure of air** (P_A, hPa)	**Weight in air** (W_A , g)	**Temp of water** (T_w , ˚C)	**Weight in water** (W_W , g)	ρ_A (g/cm^3)	ρ_W (g/cm^3)	ρ_S (g/cm^3)
	1								
	2								
	3								
	1								
	2								
	3								
	1								
	2								
	3								
	1								
	2								
	3								
	1								
	2								
	3								

Density of glass specimens

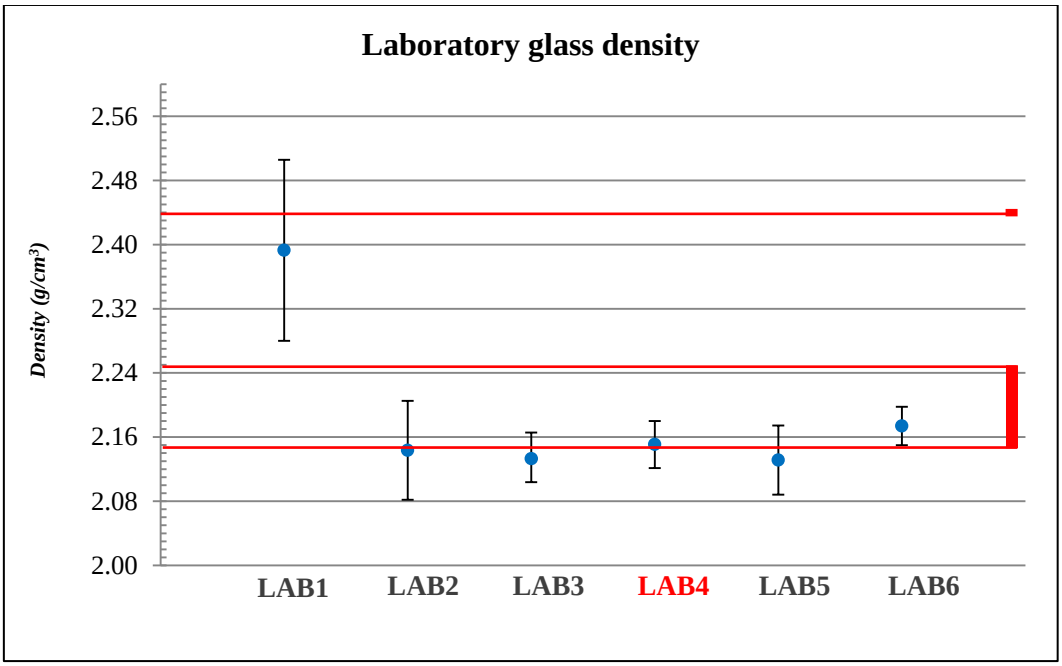
Glass samples	Appearance	$\rho_{S,av}$ ± S.D. (g/cm^3)
LAB4		2.151 ± 0.029
BOT5		2.396 ± 0.013
CAR8		2.508 ± 0.003

List of glass specimens

Glass Types		Glass sample numbers	Description
Car glass	**Common glass**	CAR1	Rear back glass (clear float glass)
		CAR2	
		CAR3	
		CAR4*	Bus glass
	Mirror glass	CAR5	Side view mirror of YAMAHA Motorcycle
		CAR6	Rear view mirror of Mercedes-Benz Original-Teile Race car
	Laminated glass	CAR7	Front windshield of NIZZAN ALMERA
		CAR8*	Bus glass
		CAR9*	
		CAR10	Front door glass of NIZZAN ALMERA
		CAR11	
		CAR12	
		CAR13	
		CAR14*	Bus glass
		CAR15*	
		CAR16	
		CAR17	
		CAR18*	Bus glass
		CAR19*	
		CAR20*	
	Tempered glass	CAR21	Extended cab glass of CARRYBOY Corporation Co., Ltd.
		CAR22*	Bus glass
		CAR23*	
		CAR24*	
		CAR25*	
Laboratory glass		LAB1	Petri dish
		LAB2	Pyrex Test tube
		LAB3	SCHOTT DURAN Beaker (250ml)
		LAB4	SCHOTT DURAN Erlenmeyer flask (250ml)
		LAB5	SCHOTT DURAN Cylinder (100ml)
		LAB6	Stirring rod
Bottle glass		BOT1	Brown color (LEO Beer of SINGHA Corporation Co., Ltd.)
		BOT2	Brown color (Coconut syrup 100% of Cofe´Corporation Co., Ltd.)
		BOT3	Green color (Sprite Carbonated beverage of COCA-COLA Company)
		BOT4	Colorless (Diet Coke Carbonated beverage of COCA-COLA Company)
		BOT5	Colorless (Singha Soda Water of SINGHA Corporation Co., Ltd.)
		BOT6	Colorless (Common milk bottle glass)

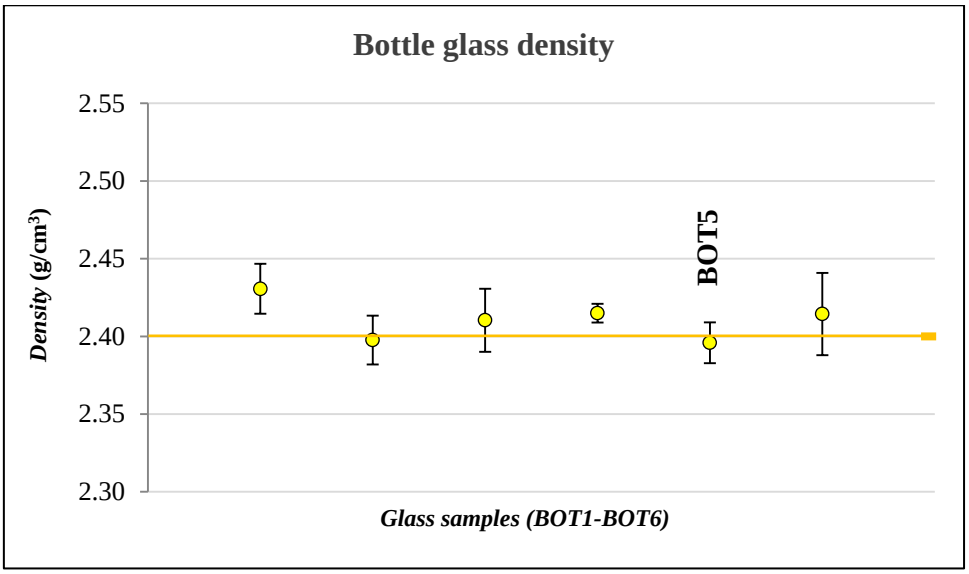
**The samples of car glass were gotten from the local automobile repair shop, which has located in Pathum Thani province.*

Density of Laboratory glass



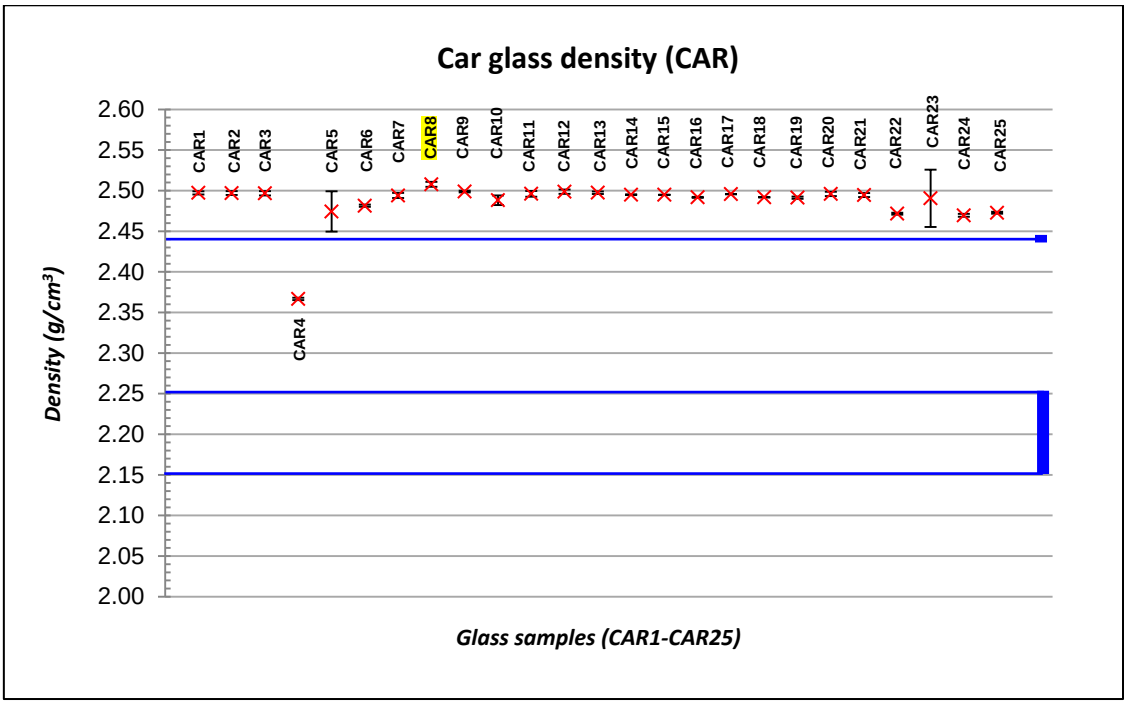
Glass samples	$\rho_{s,av}$ ± S.D. (g/cm^3)
LAB1	2.393 ± 0.113
LAB2	2.143 ± 0.062
LAB3	2.133 ± 0.032
LAB4	2.151 ± 0.029
LAB5	2.131 ± 0.043
LAB6	2.174 ± 0.024

Density of Bottle glass



Glass samples	$\rho_{S,av}$ ± S.D. (g/cm^3)
BOT1	2.431 ± 0.016
BOT2	2.398 ± 0.016
BOT3	2.410 ± 0.020
BOT4	2.415 ± 0.006
BOT5	2.396 ± 0.013
BOT6	2.414 ± 0.026

Density of Car glass



Glass samples	$\rho_{S,av} \pm$ S.D. (g/cm^3)	Glass samples	$\rho_{S,av} \pm$ S.D. (g/cm^3)	Glass samples	$\rho_{S,av} \pm$ S.D. (g/cm^3)
CAR1	2.497 ± 0.002	**CAR10**	2.488 ± 0.006	**CAR19**	2.491 ± 0.001
CAR2	2.497 ± 0.002	**CAR11**	2.496 ± 0.004	**CAR20**	2.496 ± 0.003
CAR3	2.497 ± 0.003	**CAR12**	2.499 ± 0.003	**CAR21**	2.495 ± 0.003
CAR4	2.367 ± 0.002	**CAR13**	2.497 ± 0.002	**CAR22**	2.472 ± 0.001
CAR5	2.474 ± 0.025	**CAR14**	2.4950 ± 0.0004	**CAR23**	2.491 ± 0.035
CAR6	2.481 ± 0.001	**CAR15**	2.4949 ± 0.0002	**CAR24**	2.470 ± 0.002
CAR7	2.494 ± 0.003	**CAR16**	2.4917 ± 0.0005	**CAR25**	2.473 ± 0.001
CAR8	2.508 ± 0.003	**CAR17**	2.4957 ± 0.0001		
CAR9	2.499 ± 0.001	**CAR18**	2.4917 ± 0.0003		