1.2 GRAPHING IN PHYSICS *HW/Study Packet*

SL/HL	
Required: READ Hamper pp 6-10 Tsokos, p 12, pp 14-19	Supplemental: DO Tsokos pp 19-20: # 12,14,16

REMEMBER TO….

- ✓ *Work through all of the 'example problems' in the texts as you are reading them*
- ✓ *Refer to the* ***IB Physics Guide*** *for details on what you need to know about this topic*
- ✓ *Refer to the* ***Study Guides*** *for suggested exercises to do each night*
- ✓ *First try to do these problems using only what is provided to you from the* ***IB Data Booklet***
- ✓ *Refer to the solutions/key ONLY after you have attempted the problems to the best of your ability*

UNIT OUTLINE

I. GRAPHING

A. MAKING GRAPHS
B. ERROR BARS
C. BEST FIT LINES
D. INTERPRETING LINEAR DATA

FROM THE IB DATA BOOKLET

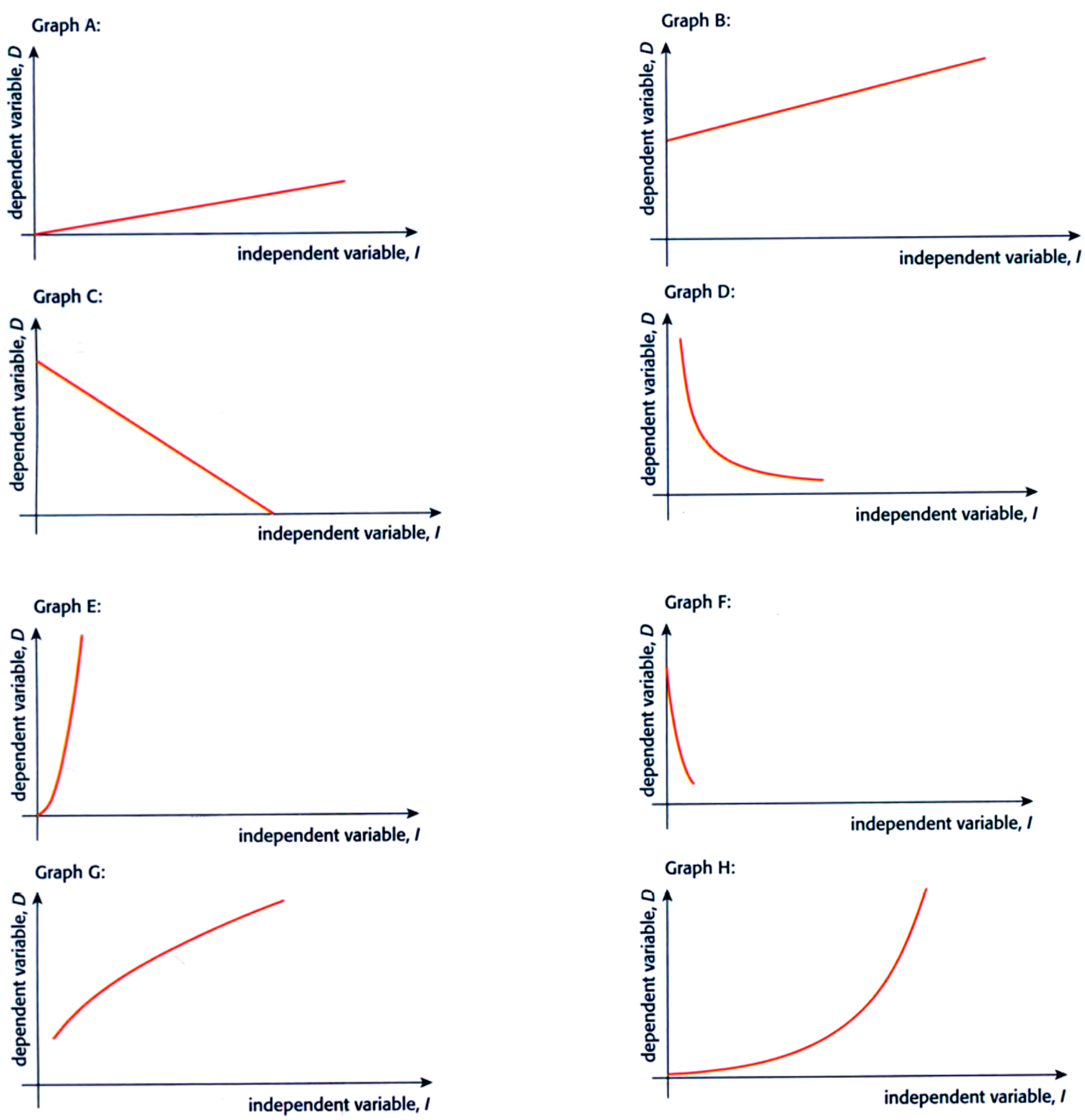
Nothing explicitly useful for this topic.

WHAT YOU SHOULD BE ABLE TO DO AT THE END OF THIS TOPIC

- □ Graph data accurately by hand and using a computer program
- □ Identify independent and dependent variables and properly graph them
- □ Insert a line of best fit (that might be a curve)
- □ Transform the variables of an equation so that a linear relationship and graph are obtained
- □ Extract relevant information from a graph (be able to describe 'what is happening' to the dependent variable as the independent variable changes)

HOMEWORK PROBLEMS:

1. For each graph A-H, suggest a relationship between y and x; in other words, guess the function y(x).*



2. A clam farmer has been keeping records concerning the water temperature and the number of clams developing from fertilized eggs. The data is recorded to the right. Graph the data and determine the optimum temperature for clam development. **[around 30°C]**

H_20 T / °C	Number of clams
15	75
20	90
25	120
30	140
35	75
40	40
45	15
50	0

3. According to Charles' Law, the volume of a gas decreases as the temperature of the gas decreases. A sample of gas was collected at 100 °C and then cooled. The changes in the volume of the sample were measured, and the data is shown below.

T / °C	V / ml
100	317
80	297
60	288
40	278
30	252
20	243
10	236
0	233
-10	227
-30	202

a) Graph the data, allowing space for extrapolation (make your x range from -300 to 120 °C, and your y range from –50 to 350 ml).

b) The temperature at which the volume of the gas reaches zero is the theoretical temperature of absolute zero. From your graph, determine the T of absolute zero in °C.

[answers will vary: around -265 °C]

4. A particle is moving in a circular path of radius *r*. The time taken for one complete revolution is *T*. The acceleration *a* of the particle is given by the expression $a = \frac{4\pi^2 r}{T^2}$. Assuming *a* and *T* are experimental variables (*r* is held constant), what would you graph in order to get a straight line and what would the slope of the line represent? **[a vs 1/T^2 ; slope gives quantity $4\pi^2 r$]**

5. The speed of sound *v* in a gas is related to the pressure *P* of the gas by the expression $v = \sqrt{kP}$

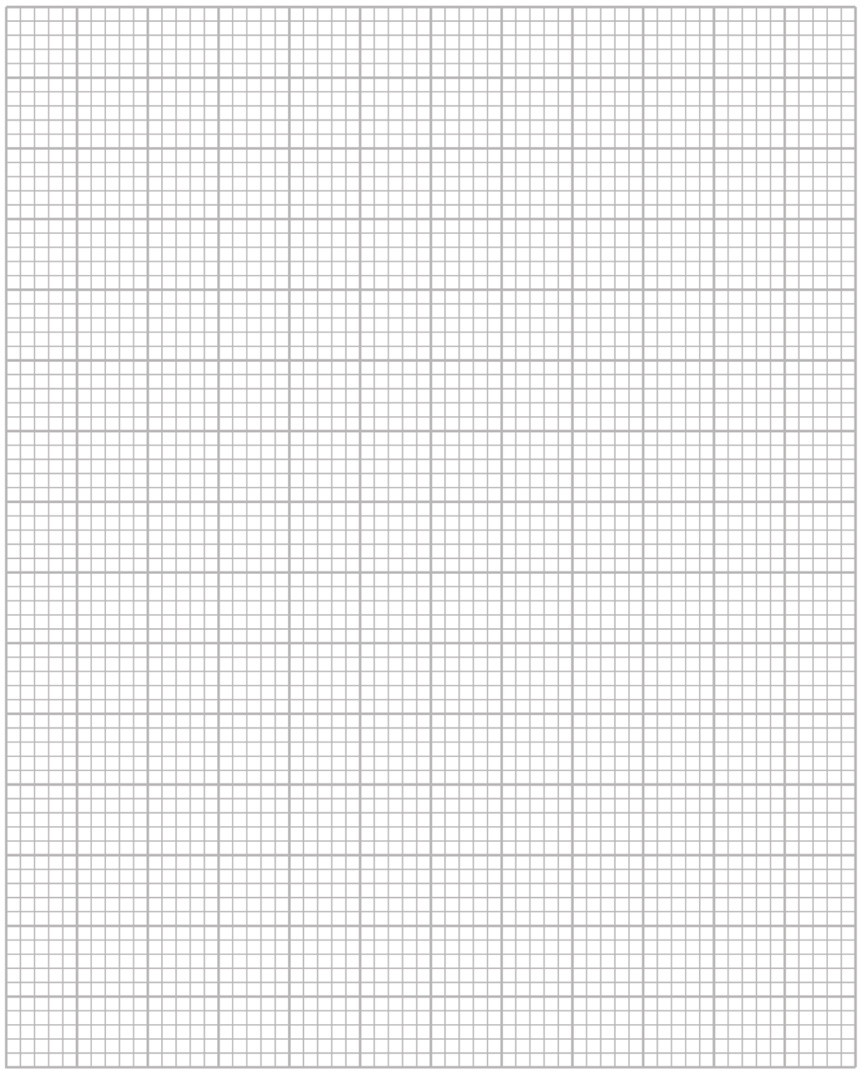
where *k* is a constant. Which variables should be plotted in order to produce a straight line graph with the slope equal to *k*? What are the units of this slope?
[v^2 vs P ; units of slope are $m^4\,N^{-1}\,s^{-2}$]

6. The variation with speed *v* of the force *F* acting on an object is given by the expression $F = pv^2 + qv$ where *p* and *q* are constants. What quantity should be plotted on the *y*-axis of a graph and what should be plotted on the *x*-axis in order to give a straight-line graph, and what are the units of the resulting gradient? **[F/v vs v ; units of slope are $N\,s^2\,m^{-2}$]**

7. The table below gives values of the resistance R of an electrical component for different values of its temperature *T*.

***T*/°C**	1.2	2.0	3.5	5.2	6.8	8.1	9.6
***R*/Ω**	3590	3480	3250	3060	2880	2770	2650

a) On the grid below, plot a graph to show the variation with temperature *T* of the resistance *R*. Show values on the temperature axis from *T* = 0°C to *T* = 10°C.



b) Draw a curve that best fits the points you have plotted. Extend your curve to cover the temperature range from 0°C to 10°C.

c) Use your graph to determine the resistance at 0°C and at 10°C.

[about 3800 Ω and 2620 Ω]

8. The thickness of the annual rings of a tree indicate what type of environmental situation was occurring at the time of its development. A thin ring, usually indicates a rough period of development, such as lack of water, forest fires, or a major insect infestation. A thick ring indicates just the opposite. Below are data for trees in two different forests:

Age of the tree / years	FOREST A: Average thickness of the annual rings / cm	FOREST B: Average thickness of the annual rings / cm
10	2.0	2.2
20	2.2	2.5
30	3.5	3.6
35	3.0	3.8
50	4.5	4.0
60	4.3	4.5

a) Graph this data, and draw in the best fit curve to the data points.

b) What was the average thickness of the annual rings of 40 year old trees in Forest A? **[~ 3.2 cm]**

c) Based on this data, what can you conclude about Forest A and Forest B?

9. The data table contains time and position data for a bicyclist riding from home on a trip.

Time / min	Distance from home / km
0	0
10	1.0
20	2.0
30	4.5
40	4.5
50	4.5
60	7.0
70	8.5
80	8.5
90	6.5

a) Graph the data and connect the points with straight lines.

b) From your graph, estimate the *position* of the bicycle at 45 min. and 75 min. **[4.5 km and 8.5 km]**

c) From your graph, estimate the *speed* of the bicycle at 40 min. and 65 min. **[0 km min^{-1} and 0.15 km min^{-1}]**

d) During what time intervals is the bicycle going the fastest? Is the bicycle ever at rest? If so, during what time interval(s)? **[fastest: 20-30, 50-60 min; at rest: 30-50, 70-80 min]**

10. The data table shows experimental time and position data for a moving object (distance measured from a stationary point).

Time / s	Position / cm
0.0	8.0
1.0	4.1
2.0	-4.0
3.0	-7.9
4.0	-4.0
5.0	4.2
6.0	8.1
7.0	4.0
8.0	-4.1
9.0	-8.0
10.0	-3.9
11.0	4.1
12.0	7.9

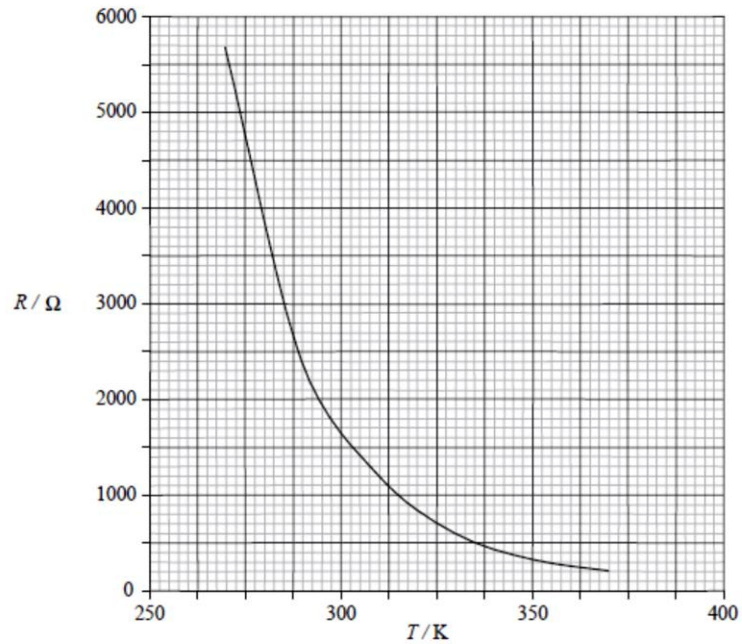
a) Make a proper line graph of this data on the grid below. Carefully draw the best fit line through your data.

b) From your graph, estimate the *position* of the object at 3.5 s and 10.5 s. **[~ -7.0 cm, 0.0 cm]**

c) From your graph, estimate the *speed* of the object at 4.5 s and 6.0 s. **[~ 8.0 cm s^{-1}, 0.0 cm s^{-1}]**

d) Briefly explain the movement of this object in a short paragraph. What do you think the object might be?

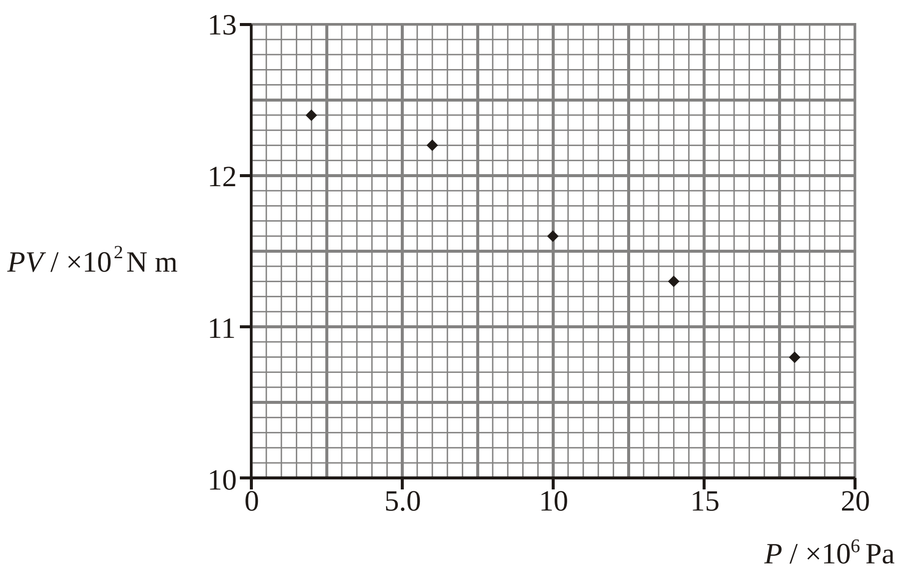
11. The graph shows the resistance R vs. temperature T for an electrical component. A student hypothesizes that resistance is inversely proportional to temperature. Use the graph to determine whether the student is correct.



12. At high pressures, a real gas does not behave as an ideal gas. For a certain range of pressures, it is suggested that the relation between the pressure P and volume V of one mole of the gas at constant temperature is given by the equation

$PV = A + BP$ where A and B are constants.

In an experiment to measure the deviation of nitrogen gas from ideal gas behaviour, 1 mole of nitrogen gas was compressed at a constant temperature of 150 K. The volume V of the gas was measured for different values of the pressure P. A graph of the product PV of pressure and volume was plotted against the pressure P and is shown below.



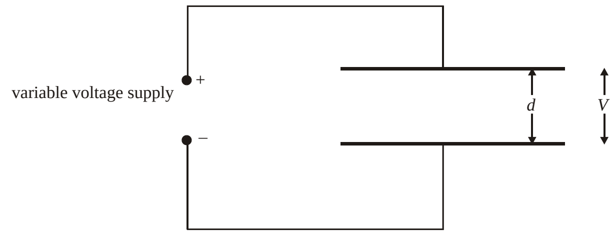
a) Draw a line of best fit for the data points.

b) Use your best fit line to determine the values (with units) of the constants A and B in the equation

$$PV = A + BP$$

[answers will vary: A = 1.3×10^3 Nm, B = -1.1×10^{-5} NmPa^{-1}]

13. The diagram shows two parallel conducting plates connected to a variable voltage supply. The plates are of equal areas and are a distance *d* apart.



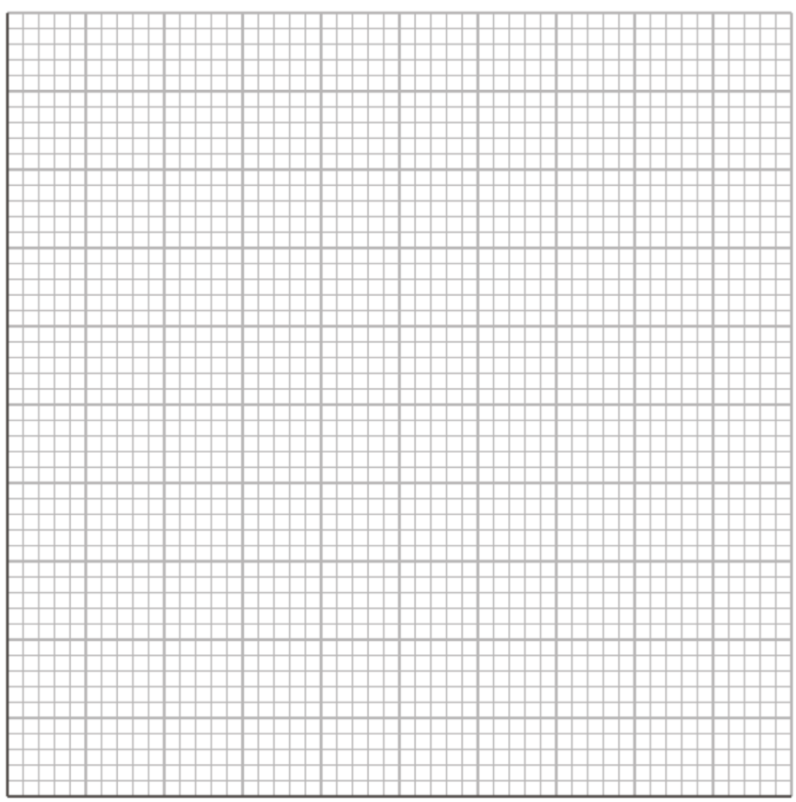
The charge *Q* on one of the plates is measured for different values of the potential difference *V* applied between the plates. The values obtained are shown in the table below. Uncertainties in the data are not included.

***V* / V**	***Q* / nC**
10.0	30
20.0	80
30.0	100
40.0	160
50.0	180

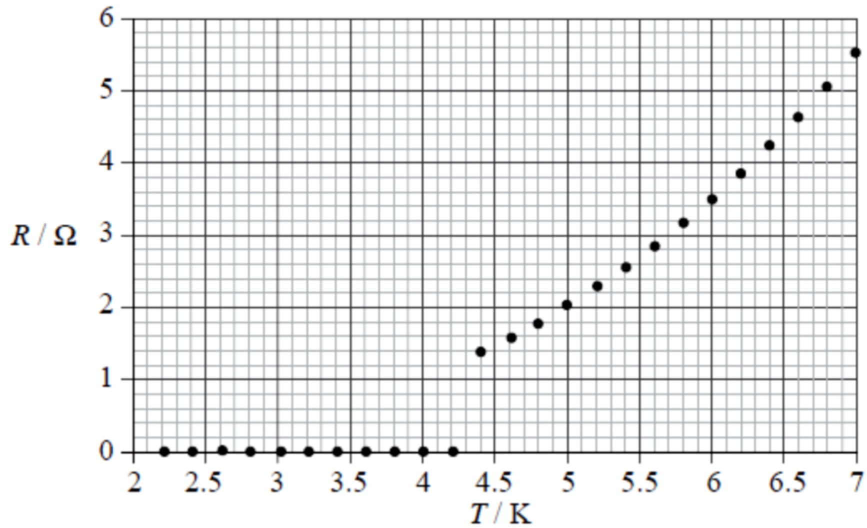
a) Plot a graph of *V* (*x*-axis) against *Q* (*y*-axis) and draw the line of best fit for the data points.

b) Determine the gradient of your best-fit line. **[answers will vary: 3.7 x 10^{-9} CV^{-1}]**

c) The gradient of the graph is a property of the two plates and is known as *capacitance*. Deduce the units of capacitance. **[CV^{-1}]**



14. The resistance R of a sample of mercury was measured as a function of temperature T of the sample. The sample was cooled, and data points were taken at temperature intervals of 0.2 K and graphed:



a) The hypothesis is that R is proportional to T for $T > 4.5$ K. Suggest whether the data supports this hypothesis and why.

b) Draw a line of best fit through the data.

c) State the value of R for which the rate of change of R of the sample with T is least. **[R = 0 Ω]**

d) At a temperature T_c, the resistance suddenly becomes zero. State a range for the possible values of T_c based on the graph. **[4.2 – 4.4 K]**

e) Outline 2 reasons why you would not use the data in the graph to determine an accurate value for R at room temperature.