**Physics @ PGS**

**A Summer Project for prospective A Level Students**

**Contents**

1 Introduction

2 Physical Quantities/Units

3 Standard Form

4 Converting Units to SI Units

5 Prefixes/Converting Unit Magnitudes

6 Re-arranging Equations

7 Using Your Calculator

8 Significant Figures

9 Solving Numerical Problems

**Physics is the science of the physical world – this ranges from subatomic particles to the edge of the universe (and everything inbetween). If we are going to consider how these quantities interact we need mathematics. In short – Maths is the language of Physics. The maths never really explains the Physics but it certainly helps us understand it.**

**These exercises have been chosen to help you settle into the course quickly. They will help you practice maths skills that are essential to being a successful Physicist and reaching your full potential.**

**Communication is key at A Level. The MOST successful students will contact me *if* there are problems *before* any work is due in. Please feel free to email me anytime at:** **r.hodge01@pudseygrangefield.co.uk**

Now let’s get started. Time to start exercising your brain again. *Most* of these activities *should* be able to be completed easily by an A Level Physicist. Some of the science will be new to you, but you should be able use the hints, where appropriate, to help you get the answer.

**TASK 1**

**Step 1**: Go to ‘isaacphysics.org’ and create a log in for yourself.

**Step 2:** Click ‘choose your questions’

**Step 3:** Choose:

‘Physics → Mechanics → Statics + Dynamics + Kinematics’

**Step 4:** Complete the activities on the grid below. Some will have more than one part to them. Write your answers in the box and click ‘check answer’.

**Step 5:** After you have completed all the activities, then please screenshot the grid and send the image in an email to r.hodge01@pudseygrangefield.co.uk by **SUNDAY 1st September.** This is NOT to check you have completed it, but allows me to see how well you have remembered to do Physics! A grid full of incorrect answers will not warrant any form of reprimand, but will allow me to target my help later on in the course.

**Step 6:** After receiving all the emails I will randomly select a question you correctly answered and you will spend 2 minutes at the whiteboard explain how you got your answer to the rest of the class. This is an essential A Level skill and I would expect you to be confident in doing this by the end of the year. You will have a week to prepare for this if you are a little nervous. Any issues, contact me.

**TASK 2**

**Chapter 1: Introduction**

One of things that many people find disconcerting when studying Physics is the idea of having to deal with lots of complicated equations. **On first sight, it can be very daunting** to see a page full of funny looking letters and symbols but with practice you will see that this really is just to save us having to write words out over and over again **(physicists like to work efficiently).**

The purpose of this introductory unit is to help you **develop the core skills** needed to solve numerical problems which will make your Year 12 Physics studies much more enjoyable and successful than they otherwise would be. Without these core skills solving problems becomes much more difficult if not impossible, a bit like trying to build a house with no wood or bricks. **A bit of work before the course starts will pay huge dividends later** and allow you to work and learn much more efficiently.

**The key to success is to break numerical problems, where calculations are necessary, into smaller, simpler steps** which can be followed every time.

The steps can be summarised as follows:-

***Step 1:*** *Write down the values of everything you are given and put a question mark next to what you are asked to work out.*

***Step 2:*** *Convert all the values into SI units i.e. time in seconds, distances in metres and so on.*

***Step 3:*** *Pick an equation that contains the values we know and the quantity we are trying to work out.*

***Step 4:*** *Re-arrange the equation so what we are trying to work out is the subject.*

***Step 5:*** *Insert the values into the equation including the units.*

***Step 6:*** *Type it into our calculator to get the answer and quote the answer to a reasonable number of significant figures and with units.*

***Step 7:*** *Pause for one moment and think about if our answer is sensible.*

With experience some of these steps can be done more quickly or in your head but you should always show your working. This is for several reasons:-

1. If you don’t show your working, you will needlessly lose many marks in the exam (probably enough to drop your score by one whole grade, i.e. from B 🡪 C).
2. It will help make the steps outlined above more apparent and easy to follow when tackling numerical problems.
3. It makes it easier for the teacher to see where you have gone wrong and therefore help you learn more quickly and effectively.

**Chapter 2: Physical Quantities/Units**

When we first look at numerical problem in Physics then we need to be able to recognise what quantities we are given in the question. This can be made a lot easier if we know what quantity corresponds to the units given in the question. For example, if a question says someone’s speed changes at a rate of 5 ms-2, you need to be able to recognise that ms-2 is the unit of acceleration and so we know that we have been given an acceleration (even though the word acceleration wasn’t used in the question).

We can classify physical quantities as either

1. Basic: These are **fundamental** which are **defined** as being independent

There are seven basic quantities defined by the Systeme International d’Unites (SI Units). They have been defined for convenience not through necessity (force could have been chosen instead of mass). Once defined we can make measurements using the correct unit and measure with direct comparison to that unit.

|  |  |
| --- | --- |
| Basic quantity | Unit |
| Name | Symbol |
| Mass | Kilogram | kg  |
| Length | Metre | m  |
| Time | Second | s |
| Electric current | Ampere | A  |
| Temperature | Kelvin | K |
| Amount of a substance | Mole | mol |
| Luminous intensity | Candela | cd |

NOTE: Base units are also referred to as dimensions.

1. Derived: These are obtained by multiplication or division of the basic units **without** numerical factors. For example:

|  |  |
| --- | --- |
| Derived quantity | Unit |
| Name | Symbols used |
| Volume | Cubic metre | m3 |
| Velocity | Metre per second | ms-1 |
| Density | Kilogram per cubic metre | kgm-3 |

Some derived SI units are complicated and are given a simpler name with a unit defined in terms of the base units.

**Farad** (F) is given as m-2kg-1s4A2  **Watt**  (W) is given as m2kgs-3

A table of quantities with their units is shown on the next page along with the most commonly used symbols for both the quantities and units.

**Note that in GCSE we wrote units like metres per second in the format of m/s but in A-level it is written as ms-1, and this is the standard way units are written at university level in science.**

**FOR YOUR REFERENCE...**

|  |  |  |  |
| --- | --- | --- | --- |
| Quantity | Quantity Symbol | SI Unit | Unit Symbol |
| Length | L or l | Metre | m |
| Distance | s | Metre | m |
| Height | h | Metre | m |
| Thickness (of a Wire) | d | Metre | m |
| Wavelength | λ | Metre | m |
| Mass | m or M | kilogram | kg |
| Time | t | second | s |
| Period | T | second | s |
| Temperature | T | Kelvin | K |
| Current | I | Ampere | A |
| Potential Difference | V | Volt | V |
| Area | A | Metres squared | m2 |
| Volume | V | Metres cubed | m3 |
| Density | ρ | Kilograms per metre cubed | kg m-3 |
| Force | F | Newton | N |
| Initial Velocity | u | Metres per second | ms-1 |
| Final Velocity | v | Metres per second | ms-1 |
| Energy | E | Joule | J |
| Kinetic Energy | EK | Joule | J |
| Work Done | W | Joule | J |
| Power | P | Watt | W |
| Luminosity | L | Watt | W |
| Frequency | f | Hertz | Hz |
| Charge | Q | Coulomb | C |
| Resistance | R | Ohm | Ω |
| Electromotive Force | ε | Volt | V |
| Resistivity | ρ | Ohm Metre | Ωm |
| Work Function | φ | Joule | J |
| Momentum | p | kilogram metres per second | kg ms-1 |
| Specific Charge |  | Coulombs per kilogram | C kg-1 |
| Planck’s Constant | h | Joule seconds | Js |
| Gravitational Field Strength | g | Newtons per kilogram | N kg-1 |

**I do not need you to memorise this, but over Y12 you will encounter every term in this table. A lot of them you will already know, so don’t panic!**

**Exercise 1 (Answer grid at back for all questions)**

For each of the following questions write down the quantities you are trying to work out and write a question mark next to the quantity you are asked to find out with SI units shown. Note that you don’t have to know any equations or any of the underlying physics to do this, it is a simply an exercise in recognising what you are being given in the question and what you are being asked to find out.

**Example**

Find the momentum of a 70 kg ball rolling at 2 ms-1.

**ANSWER: m=70 kg, v= 2 ms-1, p= ? kgms-1 NO NEED TO WORK IT OUT!**

1. The resultant force on a body of mass 4.0 kg is 20 N. What is the acceleration of the body?
2. A particle which is moving in a straight line with a velocity of 15 ms-1 accelerates uniformly for 3.0s, increasing its velocity to 45 ms-1. What distance does it travel whilst accelerating?
3. A man of mass 75 kg climbs 300 m in 30 minutes. At what rate is he working?
4. What is the maximum speed at which a car can travel along a level road when its engine is developing 24kW and there is a resistance to motion of 800 N?
5. What is the resistance of a copper cylinder of length 12 cm and cross-sectional area 0.40 cm2 (Resistivity of copper = 1.7 × 10-8 Ωm)?
6. When a 12 V battery (i.e. a battery of EMF 12 V) is connected across a lamp with a resistance of 6.8 ohms, the potential difference across the lamp is 10.2 V. Find the current through the lamp.

**Chapter 3: Standard Form**

You may well already be familiar with Standard Form from GCSE Maths, but just in case you aren’t or could do with refreshing your memory then this chapter will explain what it is and why we use it.

Why use standard form? Standard **form is used to make very large or very small numbers easier to read.** Standard form also makes it easier to put large or small numbers in order of size.

In Physics, we often deal with quantities that are either really large, such as a parsec

1 pc = 30,900,000,000,000,000 m

Or really small like Planck’s Constant h = 0.000000000000000000000000000000000663 Js

Now, it would be tiresome to write out numbers like this over and over again and so we use a different notation known as standard form. Standard form shows the magnitude (size) of the number as powers of ten. We write a number between 1 and 10 and then show it multiplied by a power of 10.

For example 1.234 **x** **104** 1.234 **x 10-4**

This means 1.234 **x** **( 10 x 10 x 10 x 10 )** 1.234 **x ( 1 ÷ 10 ÷ 10 ÷ 10 ÷ 10 )**

Which is 12340 0.0001234

Let’s see some more examples.

0.523 = 5.23 × 10-1 (note that × 10-1 means divide 5.23 by 10)

52.3 = 5.23 × 101 (note that × 101 means multiply 5.23 by 10)

523 = 5.23 × 102 (note that × 102 means multiply 5.23 by 100)

5230 = 5.23 × 103 (note that × 103 means multiply 5.23 by 1000)

0.00523 = 5.23 × 10-3 (note that × 10-3 means divide 5.23 by 1000)

Note that the sign (positive or negative) in the index tells you whether you are dividing or multiplying; a positive number means you are multiplying and a negative number means you are dividing. The number tells you how many times you are either dividing or multiplying by 10. So 1.60 × 10-19 means take the number 1.60 and divide it by 10 nineteen times (divide by 1019) i.e. move the decimal point 19 places to the left.

And to go back to our examples from above:-

1 pc = 3.09 × 1016 m

h= 6.63 × 10-34 Js So this is a much shorter way of writing these numbers!

To put a list of large numbers in order is difficult because it takes time to count the number of digits and hence determine the magnitude of the number.

**Exercise 2**

1. Put these numbers in order of size,

5.239 x 106 , 2563 x 107 , 5.682 x 106 , 8.635 x 107 , 1.258 x 109 1.425 x 108 , 6.485 x 108

You can see that it is easier to work with large numbers written in standard form. To do this we must be able to convert from one form into the other.

2. Convert these numbers into normal form.

 a) 5.239 x 103 b) 4.543 x 104 c) 9.382 x 102 d) 6.665 x 106

 e) 1.951 x 102 f) 1.905 x 105 g) 6.005 x 103

3. Convert these numbers into standard form.

 a) 65345 (how many times do you multiply 6.5345 by 10 to get 65345 ?)

 b) 28748 c) 548454 d) 486856 e) 70241 f) 65865758 g) 765

Standard form can also be used to write small numbers

 e.g. 0.00056 = 5.6 × 10­­­­-4

1. Convert these numbers into normal form.

a) 8.34 × 10-3 b) 2.541 × 10-8 c) 1.01 × 10-5 d) 8.88 × 10-1 e) 9 × 10-2 f) 5.05 × 10-9

1. Convert these numbers to standard form.

a) 0.000567 b) 0.987 c) 0.0052 d) 0.0000605 e) 0.008 f) 0.0040302

**Chapter 4: Converting Units to SI Units**

Some common non-SI units that you will encounter during A level Physics:-

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quantity | Quantity Symbol | Alternative Unit | Unit Symbol | Value in SI Units |
| Energy | E | electron volt | eV | 1.6 × 10-19 J |
| Charge | Q | charge on electron | e | 1.6 × 10-19 C |
| Mass | m | atomic mass unit | u | 1.67 × 10-27 J |
| Mass | m | tonne | t | 103 kg |
| Time | t | hour | hr | 3,600 s |
| Time | t | year | yr | 3.16 × 107 s |
| Distance | d | miles | miles | 1,609 m |
| Distance | d | astronomical unit | AU | 3.09 × 1011 m |
| Distance | d | light year | ly | 9.46 × 1015 m |
| Distance | d | parsec | pc | 3.09 × 1016 m |

**It is essential that you recognise these units and also know how to change them to SI units and back again. A lot of marks can be lost if you are not absolutely competent doing this.**

When you are converting from these units to SI units you need to multiply by the value in the right hand column. When you convert back the other way you need to divide.

**Example**

The nearest star (other than the Sun) to Earth is Proxima Centauri at a distance of 4.24 light years.

What is this distance expressed in metres?

4.24 light years = 4.24 × 9.46 × 1015 m = 4.01 × 1016 m

What is this distance expressed in parsecs?

4.01 × 1016 m = 4.01 × 1016 / 3.09 × 1016 m = 1.30 pc

**Exercise 3**

Convert the following quantities:-

1. What is 13.6 eV expressed in joules?
2. What is a charge of 6e expressed in coulombs?
3. An atom of Lead-208 has a mass of 207.9766521 u, convert this mass into kg.
4. What is 2.39 × 108 kg in tonnes?
5. It has been 44 years since England won the World Cup, how long is this in seconds?

**Chapter 5: Prefixes & Converting Unit Magnitudes**

**How to use and convert prefixes**

Often in Physics, quantities are written using prefixes which is an even shorter way of writing numbers than standard form. For example instead of writing 2.95 × 10-9 m we can write 2.95 nm where n means nano and is a short way of writing × 10-9. Here is a table that shows all the prefixes you need to know in Year 12 Physics.

|  |  |  |  |
| --- | --- | --- | --- |
| **Prefix** | **Symbol** | **Name** | **Multiplier** |
| femto | f | quadrillionth | 10-15 |
| pico | p | trillionth | 10-12 |
| nano | n | billionth | 10-9 |
| micro | µ | millionth | 10-6 |
| milli | m | thousandth | 10-3 |
| centi | c | hundredth | 10-2 |
| deci | d | tenth | 10-1 |
| deka | da | ten | 101 |
| hecto | h | hundred | 102 |
| kilo | k | thousand | 103 |
| mega | M | million | 106 |
| giga | G | billion† | 109 |
| tera | T | trillion† | 1012 |
| peta | P | quadrillion | 1015 |

**Again, it is essential you know all of these to ensure that you don’t lose easy marks when answering numerical problems.** When you are given a variable with a prefix you must convert it into its numerical equivalent in standard form before you use it in an equation.

Always start by replacing the prefix symbol with its equivalent multiplier.

For example: 0.16 μA = 0.16 x 10-6 A = 0.00000016A

 3 km = 3000m = 3 x 103 m

 10 ns = 10 x 10-9 s = 0.00000001 s

**DO NOT** get tempted to follow this further (for example: 0.16 x 10-6 A = 1.6 x 10-7 A and also 10 x 10-9 s = 10-8 s) unless you are absolutely confident that you will do it correctly. It is always safer to stop at the first step (10 x 10-9 s) and type it like this into your calculator.

**Exercise 4**

1. 24kW is how many Watts?
2. 10 μC is how many Coulombs?
3. 340 MW is how many Watts?
4. 46 pF is how many Farads?
5. 0.03 MN is how many Newtons?

**Exercise 5**

Convert the following: (Remember that milli = 10-3 and centi = 10-2)

1. 5.46m to cm
2. 65mm to m
3. 3. 3cm to m
4. 0.98m to mm
5. 34cm to mm
6. 76mm to cm

**Converting between unit magnitudes for areas and volumes**

It’s really important that when we convert areas and volumes that we don’t forget to square or cube the unit.

**Example**

Let’s take the example of converting a sugar cube of volume 1 cm3 into m3. If we just use the normal conversion, then 1 cm3 = 1 x 10-2 m3 **🡨 Wrong Answer!** STOP! Let’s think about this one second:

Imagine in your head a box 1m by 1m by 1m, how many sugar cubes could you fit in there? A **lot** more than 100! That would only fill up one line along one of the bottom edges of the box! **So our answer must be wrong.** What we have to do is do the conversion and then cube it, like this:-

1 cm3 = 1 (x 10-2 m)3 = 1 x 10-6 m3. So this means we could fit a million sugar cubes in the box.

**Exercise 6**

1. What is 5.2 mm3 in m3?
2. What is 24cm2 in m2?
3. What is 34 m3 in μm3?

**Chapter 6: Re-arranging Equations**

The first step in learning to manipulate an equation is your ability to see how it is done once and then **repeat the process again and again until it becomes second nature to you**.

In order to show the process once I will be using letters rather than physical concepts.

You can rearrange an equation  with

 as the subject 

or  as the subject 

**Worked examples**

|  |  |  |
| --- | --- | --- |
| Equation | First Rearrangement | Second Rearrangement |
|  |  |  |
|  |  |  |
|  |  |  |

**From now on the multiplication sign will not be shown, so will be simply written as **

**Exercise 7 – Please complete in answer booklet, not here.**

|  |  |  |
| --- | --- | --- |
| Equation | First Rearrangement | Second Rearrangement |
| (Power of lens)  |  |  |
| (Magnification of lens)  |  |  |
| (refractive index)  |  |  |
| (current)  |  |  |
| (electric potential)  |  |  |
| (power)  |  |  |
| (power)  |  |  |
| (conductance)  |  |  |
| (resistance)  |  |  |
| (resistance)  |  |  |
| (power)  |  |  |
| (power)  |  |  |
| (stress)  |  |  |

**Chapter 7: Using Your Calculator**

**Order of Operations**

Your calculator has a rule to decide which operation to do first which is summarised by the word BODMAS, which stands for the order in which operations are done:-

1. B - Brackets first
2. O - Orders (i.e. Powers and Square Roots, etc.)
3. DM - Division and Multiplication (left-to-right)
4. AS - Addition and Subtraction (left-to-right)

So if we type in the numbers like this:-

30 ÷ 5 × 3 = 6 × 3 = 18   🡨 Left to Right is the conventional order and is what your calculator does.

But if we use brackets we can get the right answer:-

30 ÷ (5 × 3) =30 ÷ 15= 2

Note that the fact that the 5 and 3 are put on the bottom implies they should be multiplied first.

**You will need to be able to use your calculator correctly and be familiar with scientific notation, such as standard form, brackets etc.**

e.g. 3 670 000 = 3.67 x 106

 0.0 000 367 = 3.67 x 10-4

To enter 3.67 x 106 into your calculator press:

3.67 exp 6

**Note that 108 means 1 x 108 and so must be keyed in as 1 exp 8 not 10 exp 8! As a result write out 1 x 108 to remind yourself to do this.**

## Exercise 8

## Always give your answer in standard form, e.g. 7.0 x 10-3 and not as 7.0-3, which is how it is displayed on the calculator. Your answer should have the same amount of significant figures as the question.

1. (7.5 x 103) x (24) 2. (6.2 x 10-5) x (5.0 x 10-3) 3. (1.4 x 105) x (2.0 x 104)

4. 4.5 x 103 / 7.0 x 104 5. 3 x 10-6 / 6.0 x 103

**Chapter 8: Significant Figures**

**You can lose a mark if you quote too many significant figures in an answer**. It is not as bad a leaving off a unit when answering a question – but why lose marks needlessly when you don’t have to?

**The Rules**

1. All non-zero digits are significant.

2. In a number without a decimal point, only zeros BETWEEN non-zero digits are significant. E.g. significant in 12001 but not in 12100

 3. In a number with a decimal point, all zeros to the right of the right-most non-zero digit are significant. 12.100 🡪 5 s.f.

**Examples**

39.389 🡪 5 s.f.

120000000000000🡪 2 s.f

3400.000 🡪 7 s.f.

34224000 🡪 5 s.f.

200000.0004 🡪 10 s.f.

**Exercise 9**

How many significant figures are the following numbers quoted to?

1. 224.4343
2. 0.00000000003244654
3. 3442.34
4. 200000
5. 43.0002
6. 24540000
7. 543325
8. 23.5454353
9. 4.0000000000
10. 4456001

**Exercise 10**

For the numbers above that are quoted to more than 3 s.f., convert the number to standard form and quote to 3 s.f.

**Using a Reasonable Number of s.f.**

Try to use the same s.f. as those provided in the question or just one more.

**Example:**

Let’s say we were faced with this question:

A man runs 110 metres in 13 seconds, calculate his average speed.

Distance = 110 m

Time = 13 s

Speed = Distance/Time = 110 metres / 13 seconds

=8.461538461538461538461538461538 ms-1

**This is a ridiculous number of significant figures!**

=8.46 m/s seems acceptable (3 s.f.) because the figures we were given in the question we given to 2 s.f, so we’ve used just one more than that in our answer. If in doubt quote answers to 3 s.f. in the exam – this is normally close enough to what they are looking for.

**Chapter 9: Example Numerical Problems**

A Step by Step Guide on Tackling a Numerical Problem

**This example may look lengthy, but that’s because I am describing every step that I do in my head. Only the shaded bits will end up written down on my paper.**

A question says:-

*Speed of electromagnetic radiation in free space (c) = 3.00 x 108 m s-1*

*Planck’s constant (h) = 6.63 x 10-34 J s*

 *Calculate the energies of a quantum of electromagnetic radiation of the following wavelength: 10-3 nm*

***Step 1:*** *Write down the values of everything you are given and put a question mark next to what you are asked to work out:-*

**c = 3.00 × 108 ms-1**

**h = 6.63 × 10-34 Js**

**λ = 10-3 nm**

**E = ?**

***Step 2:*** *Convert all the values into SI units i.e. time in seconds, distances in metres and so on:-*

**c = 3.00 × 108 ms-1**

**h = 6.63 × 10-34 Js**

**λ = 10-3 nm**

**E = ?**

From before nm = 10-9 m

So now replace nm with 10-9 m:-

λ = 10-3 nm = 10-3 × 10-9 m = 10-12 m = 1 × 10-12 m

So our list of known values becomes:-

**c = 3.00 × 108 ms-1**

**h = 6.63 × 10-34 Js**

**λ = 10-3 nm = 1 × 10-12 m**

**E = ?**

***Step 3:*** *Pick an equation that contains the values we know and the quantity we are trying to work out:-*

So we want an equation with c, h, λ and E in it. The one for photon energy is this:



***Step 4:*** *Re-arrange the equation so what we are trying to work out is the subject.*

We got lucky this time, the thing we are trying work out is the Energy, E, and that is already the subject, so no re-arranging to do!

***Step 5:*** *Insert the values into the equation:-*



***Step 6:*** *Type it into our calculator to get the answer and quote the answer to a reasonable number of significant figures:-*

Answer in the calculator:



The values for h and c were quoted to 3 significant figures, the value for λ was only quoted to 1 s.f. but it’s not clear whether this actually was an exact value or rounded to 1 s.f.. Quoting our answer to 3 significant figures seems reasonable. (If in doubt, quote to 3 significant figures, you won’t be too far wrong.)



***Step 7:*** *Pause for one moment and think about if our answer is sensible.*

**Answers**

**Exercise 1:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 2:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3a. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3b. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3c. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3d. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3e. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3f. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3g. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4a. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4b. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4c. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4d. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4e. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4f. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4g. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5a. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5b. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5c. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5d. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5e. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5f. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6a. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6b. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6c. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6d. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6e. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6f. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 3**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 4:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 5:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 6:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 7**

|  |  |  |
| --- | --- | --- |
| Equation | First Rearrangement | Second Rearrangement |
| (Power of lens)  |  |  |
| (Magnification of lens)  |  |  |
| (refractive index)  |  |  |
| (current)  |  |  |
| (electric potential)  |  |  |
| (power)  |  |  |
| (power)  |  |  |
| (conductance)  |  |  |
| (resistance)  |  |  |
| (resistance)  |  |  |
| (power)  |  |  |
| (power)  |  |  |
| (stress)  |  |  |
| (strain)  |  |  |

**Exercise 8:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 9:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Exercise 11:**

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_