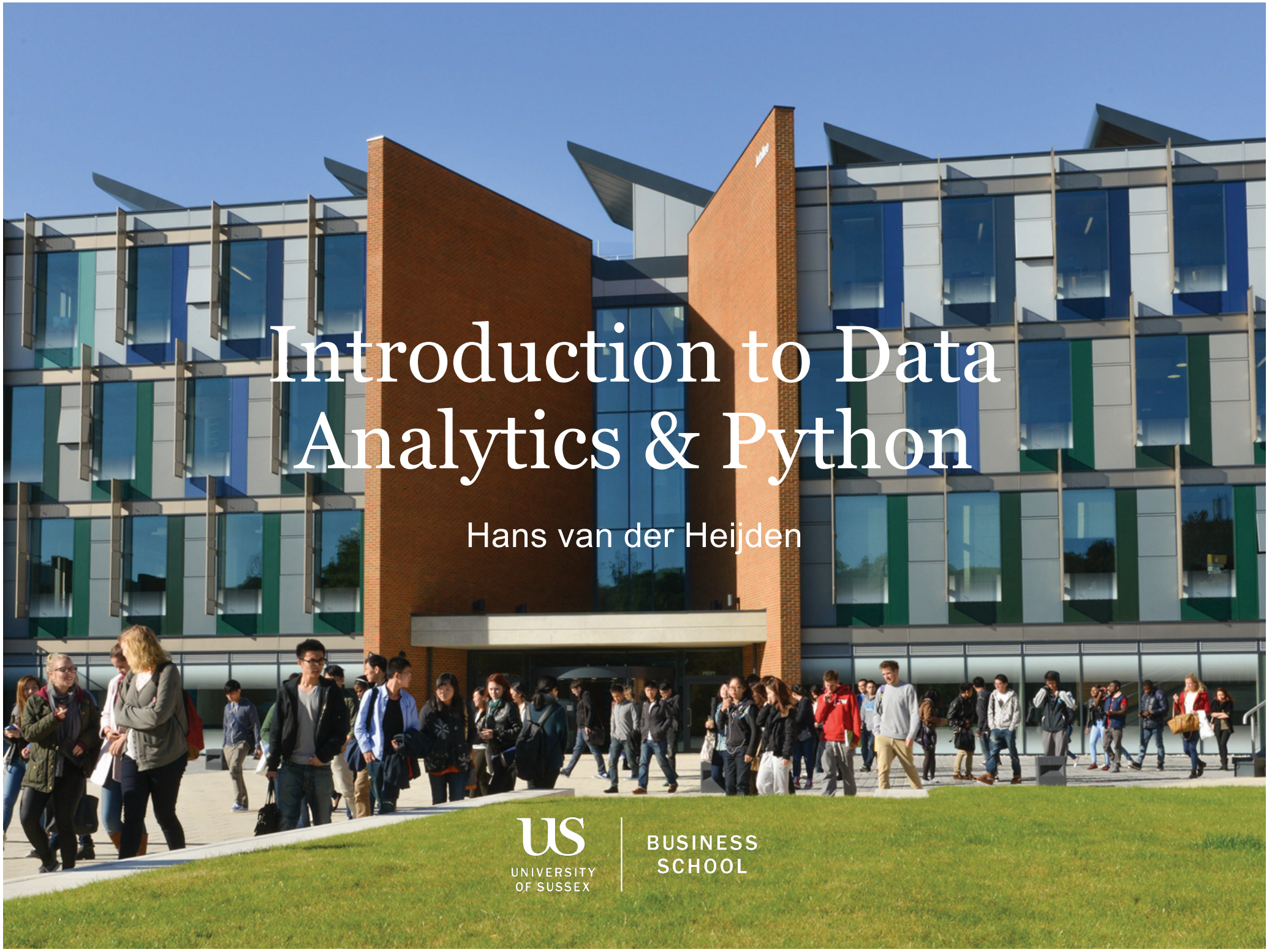
Introduction to Data Analytics & Python
Hans van der Heijden
UNIVERSITY OF SUSSEX
BUSINESS SCHOOL

Learning outcomes

- To understand and appreciate the tools of data science, in an accounting context
- To be able to detect unusual transactions in large business data sets
- To be able to articulate why they are unusual

Agenda

1. Why data science
2. Introduction to Python
3. Example: Three-way match in procure-to-pay
4. Three-way match in Python

Why data science?

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Business Data

Tesco

- 70 transactions per second
- 6 million transactions per day

Amazon

- 306 transactions per second
- 26.4 million transactions per day

- Twitter
  - 6000 tweets per second
  - 500 million tweets per day

Data science

The role of data science is to take raw business data and turn it into something meaningful, ie. an insight, a trend, an answer to a specific question

Input: Raw Data

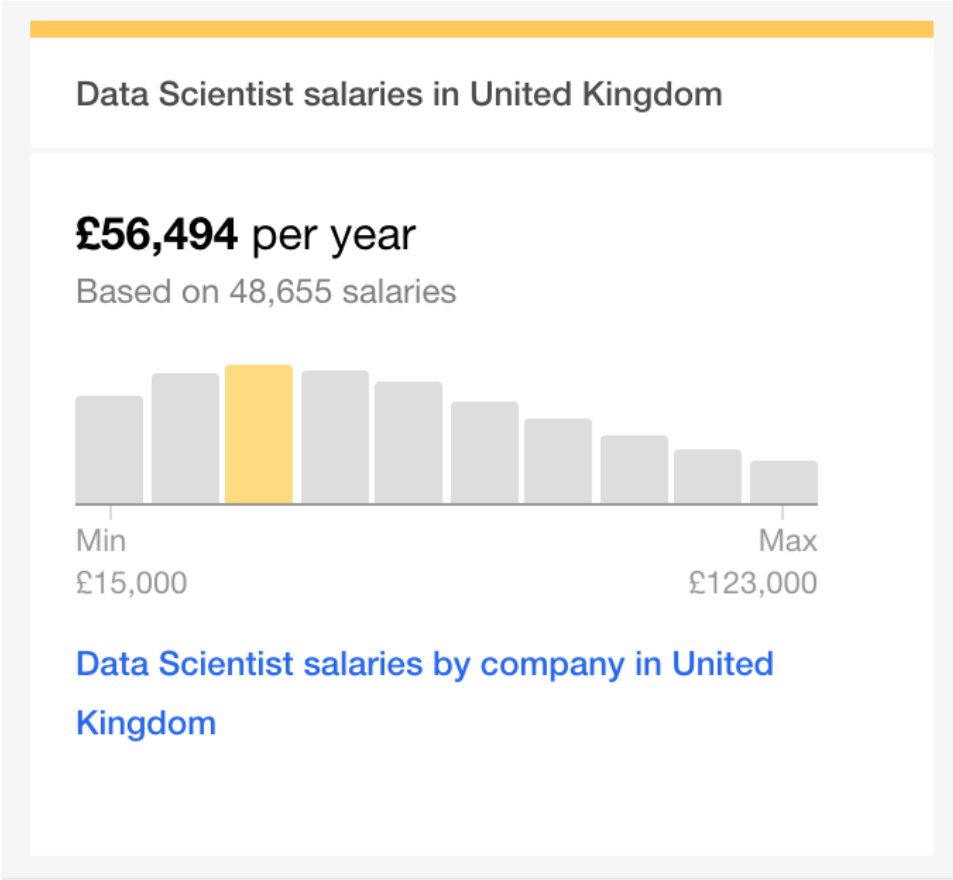
- Large tabular datasets

Output: Excel file

- File contains human-readable table or chart

Data science in accounting

Data scientists are in demand given the reliance on financial data in accounting, auditing, banking & finance.



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Data science, statistics, and programming

Data science is not the same as statistics but statistical techniques are often used in data science

- Summarising (using descriptive statistics)
- Forecasting (using statistics such as linear regression)

Data science is not programming (or coding) either, but programming is often used in data science as well

- E.g., creating a for-loop to go through all business transactions

Data science shortcomings

1. General expectations gap between what's possible and what's believed to be possible

2. "Garbage in / Garbage out"
   - Poor quality data can still lead to an "exact" final outcome

3. "Black box" manipulations may limit trust in final outcomes

Data science in auditing

- Past practice – sample based auditing
  - Auditor takes a sample of all transactions, audits just these, and forms opinion.
- Sampling not always adequate
  - 25 out of 80,000 transactions (insurer)
  - 10 out of 6 million mortgages (retail bank)
- New practice – population-based auditing
  - Auditor takes *all* transactions
  - Runs them through software to see which ones are suspect
  - Audits suspect transactions & forms opinion.

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Examples of checks (1)

- Any data entry made in weekend or late at night
- Any suspiciously round number
- Any payment just under particular threshold
- Any payment with a description containing the word 'bonus' or similar
- Any missing invoice number

Examples of checks (2)

- Any invoice with an outgoing payment higher than stated on purchase order or goods receipt

We will proceed with this check, and implement it in Python.

Introduction to Python

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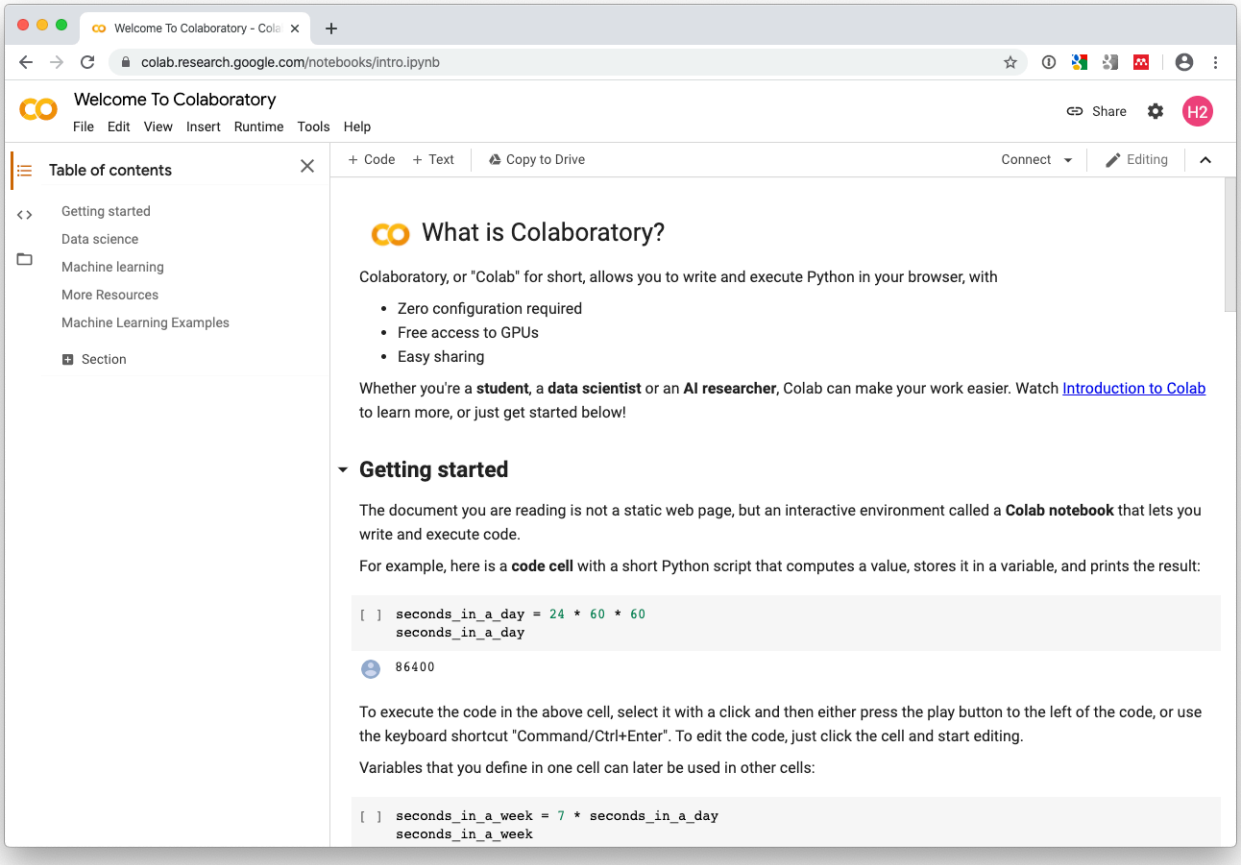
Python

- General purpose computer language
  - Created 1991 in Amsterdam
- Popular in part because of “human readability”
  - (it is easy to see what the code does)
- Named after Monty Python
- No 1 language for data science

Setting up Python

https://colab.research.google.com



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Colab basics

Notebook

- Basic structure of Colab

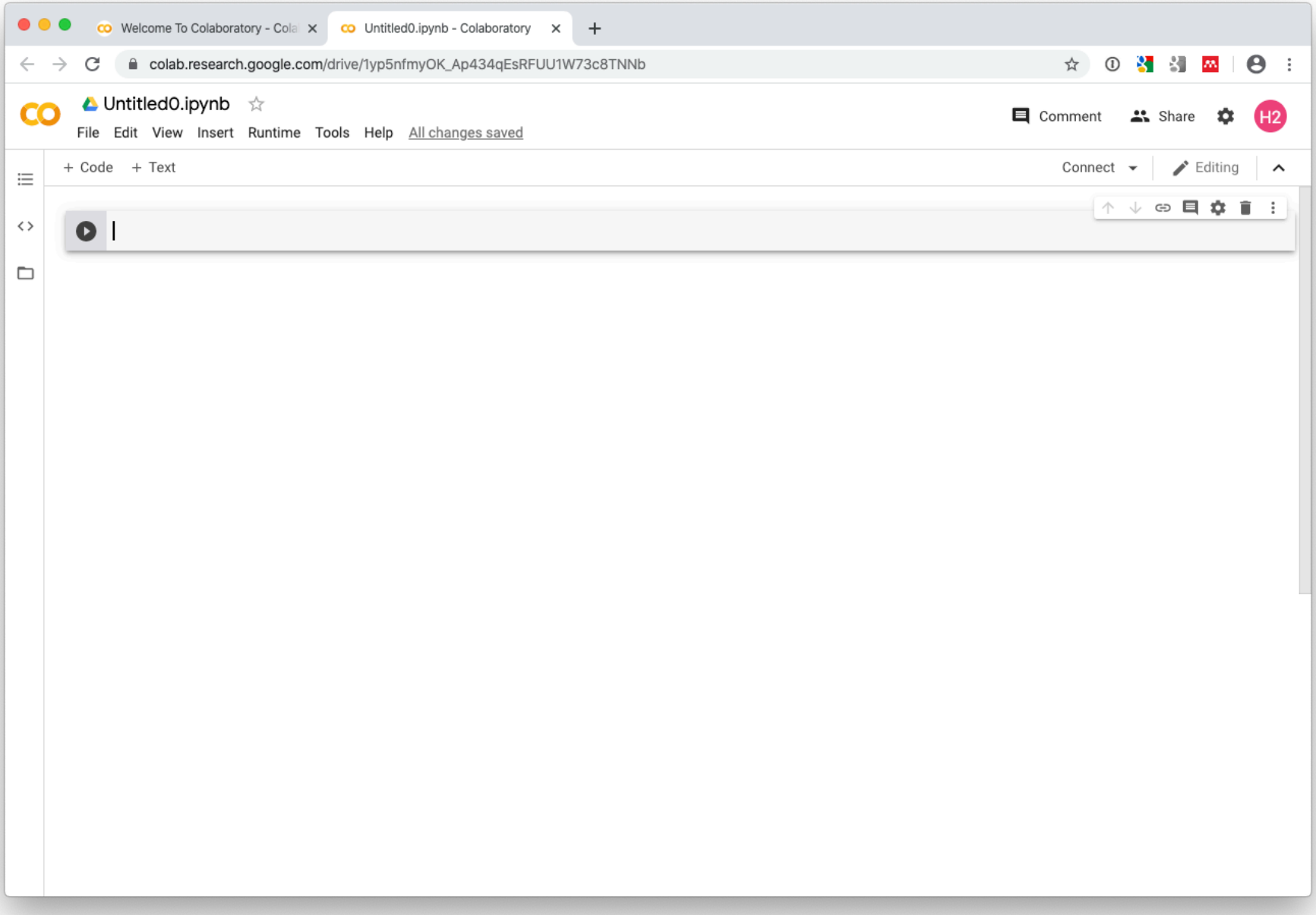
Python run-time

- A run-time is the ”engine” running your code, in our case Python

Cells

- Notebooks have cells, cells contain the code
- To ‘run’ a cell, put cursor in cell and type Shift-Enter

New notebook



Core features

- Input-Output
  - Type `print('hello world')` and press shift-enter
- Variables
- Boolean conditions (true and false)
- Functions
- Libraries

Functions

- `min(1, 2)`
- `list = (1, 2, 3, 4, 5)`
  `sum(list)`
- `round(3.2223, 2)`

These are examples of functions: they take input and produce output.

Create your own functions

```
def value(price, quantity):
    return price * quantity
```

- Starts with `def`
- Note the indent on the second line

`value(10, 100)` (shift-enter)

- 1000

Example: Three-way match in procure-to-pay

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Three-way match

Three-way match is a type of invoice verification

Three documents must match before payment goes out to a supplier

- Purchase Order (price & quantity)
- Goods Received Document (quantity)
- Invoice Received (price & quantity)

Anything unusual requires further investigation

- Potentially human error, misunderstanding, or in the worst case fraud

Three business documents

- Purchase order
  - Created by purchase department in *our* company
  - Specifies quantity & price
- Goods received
  - Created by warehouse in *our* company
  - Specified quantity, refers to purchase order
- Invoice received
  - Created by *supplier*, and then sent to *our* accounting department
  - Specifies quantity, price, total value to pay
  - Refers to purchase order

Purchase Order

Miss Red

PURCHASE ORDER

Sumigi Support's business	purchase order no	**430864**
	date	**24 Dec 2018**

Product code	Quantity	Description
85206	300	Apple Trees, less trade discount @ 20%

AUTHORISED: Signature: *Miss Red* Date: *24 Dec 2018*

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Invoice Received

Sumigi Support's business

INVOICE

Miss Blue

invoice no	**83357**
account	**MISS13**
your reference	**769031**
date	**4 Jan 2019**

Product code	Description	Quantity	Price	Unit	Total	Discount @20%	Net
85437	T-shirts	100	1.25	each	125.00	25.00	100.00

Terms
Net monthly
Carriage paid
E & OE

Goods total	100.00
VAT @21%	21.00
Grand total	121.00

An example

- Our company wishes to purchase 51 boxes of cheese at £72.07 each
  - Our purchasing department creates the purchase order and sends to supplier.
- 51 boxes of cheese arrive
  - Our warehouse creates the goods receipt document. Refers back to the purchase order.
- Cheese supplier sends invoice of £3675.57
  - Our accounting department receives the invoice. It contains the purchase order reference.
- Company pays £3675.57 to cheese supplier
  - Accounting department carries out three-way match, and if OK pays out.

Invoice verification

Invoices must always be verified, because what can happen?

1. Invoice is fake (no purchase order)
2. Invoice is premature (no goods received yet)
3. Invoice amount is incorrect (higher than price * quantity)
4. Price is different on invoice than on purchase order
5. Quantity is different on purchase order
6. Quantity is different on goods receipt

Three-way match in Python

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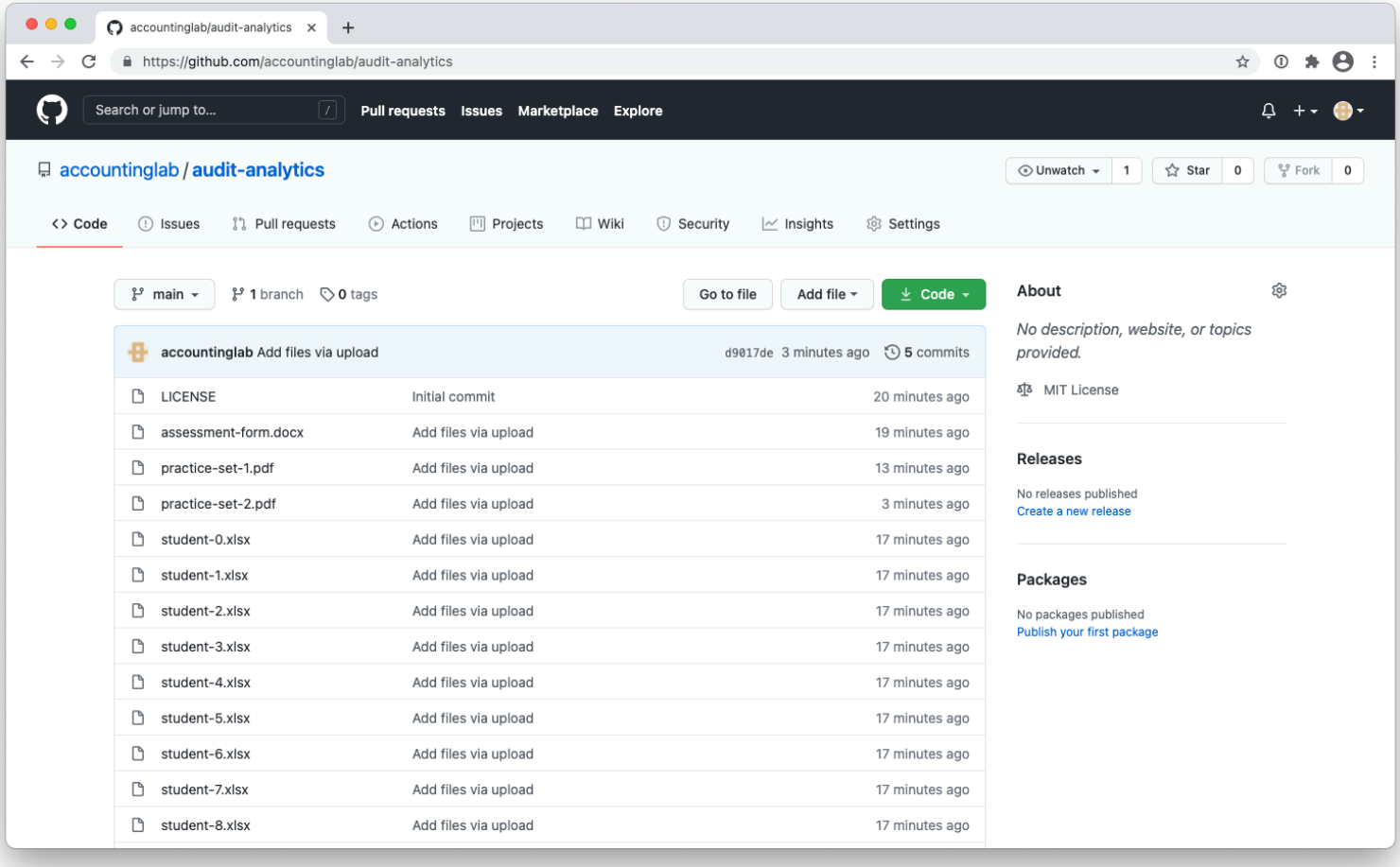
Spreadsheets

https://github.com/accountinglab/audit-analytics



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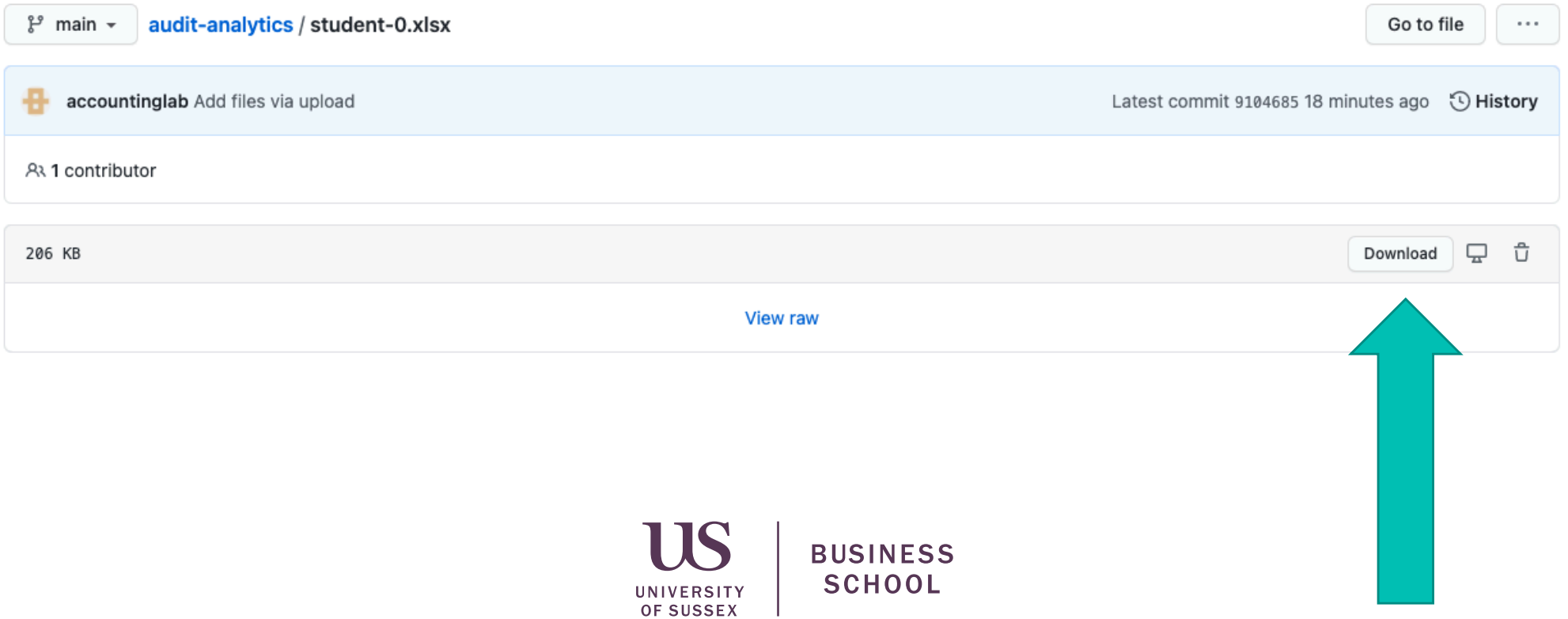
Examine your spreadsheet

Click on student-X.xlsx where X is the last digit of your student ID number

Click on 'Download'



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Examine your spreadsheet

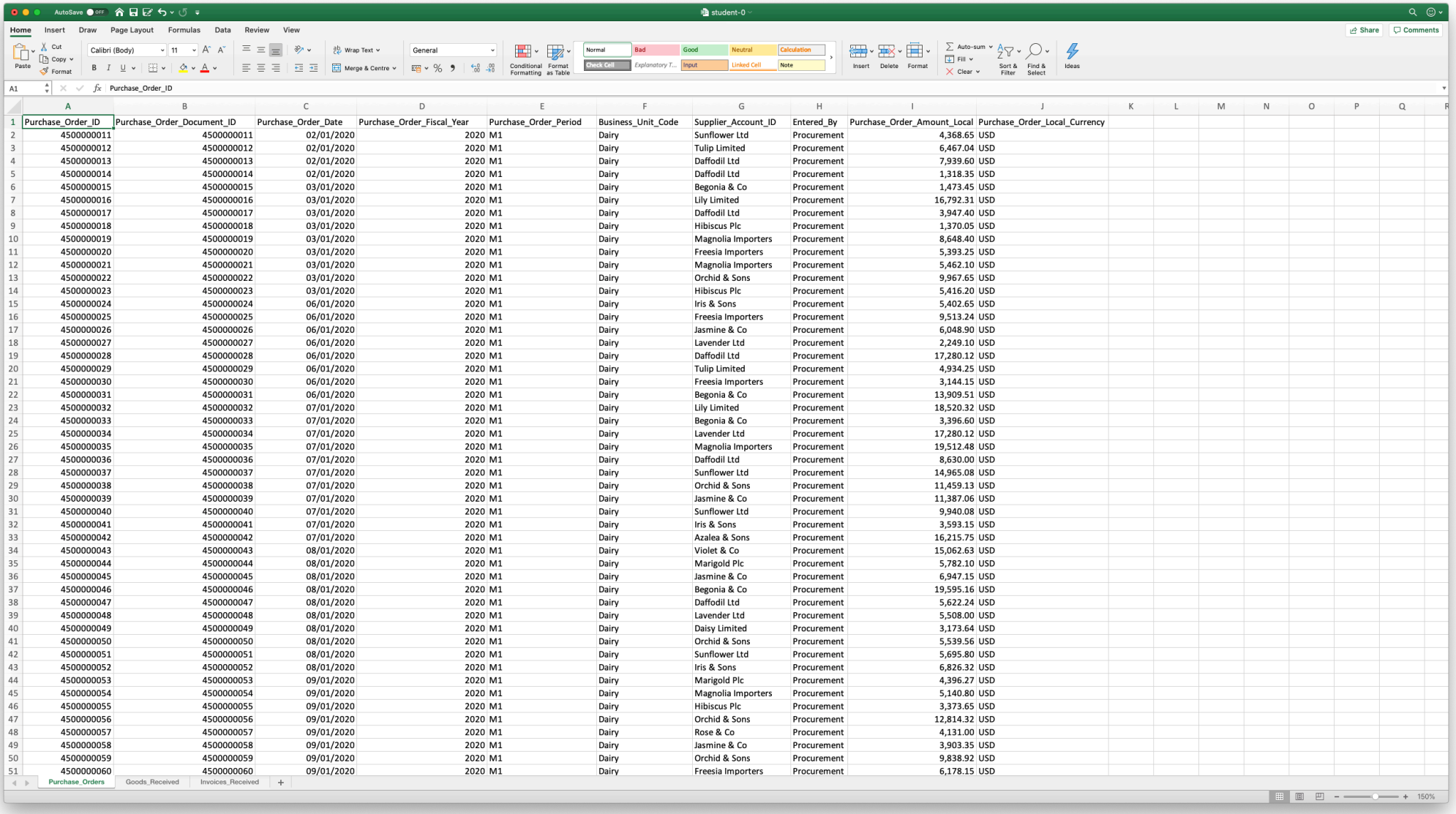
There are three worksheets in the workbook:

- Purchase Orders
- Goods Received Documents
- Invoices Received

Spreadsheet format

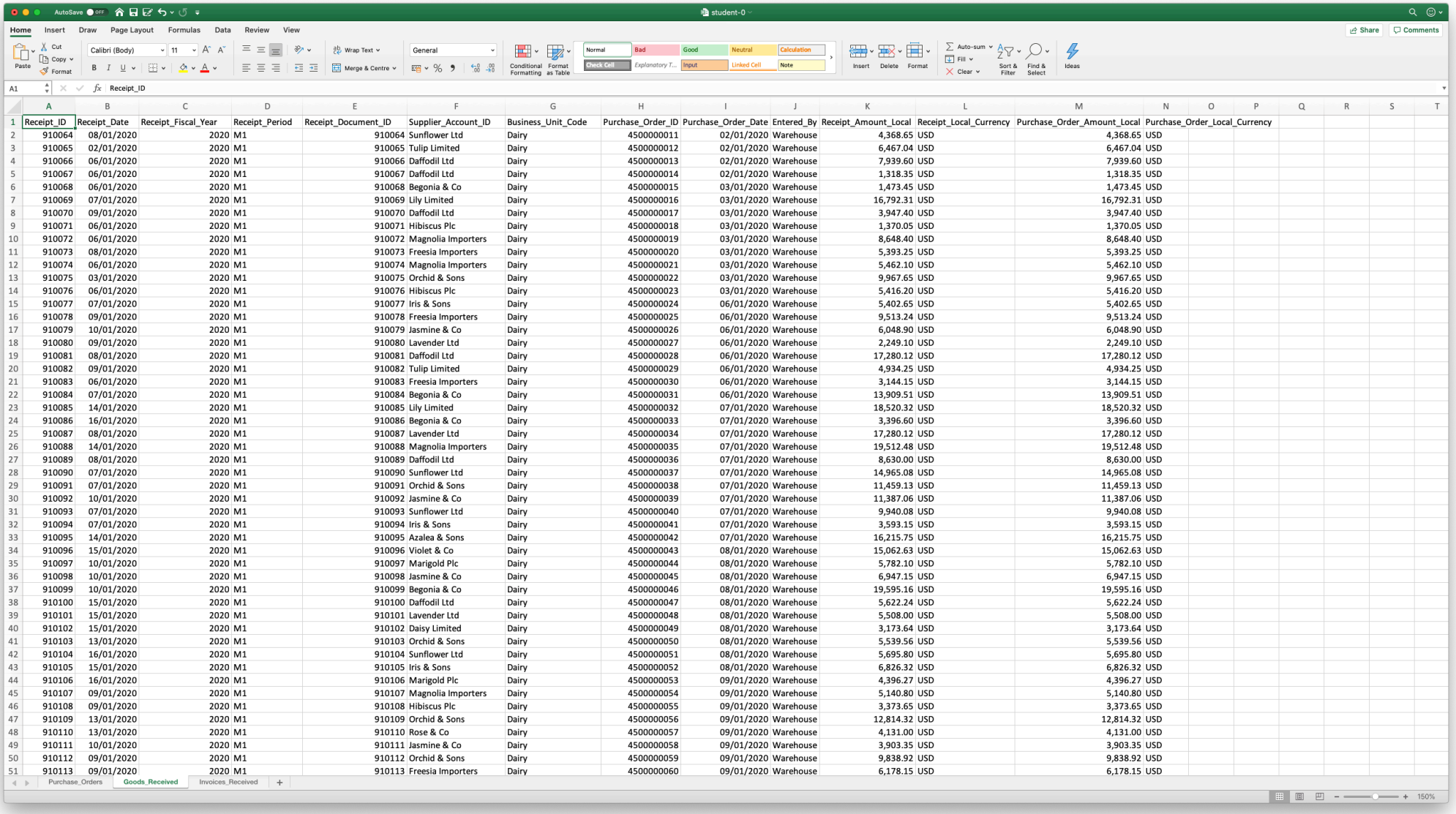
- Rows represent documents
- Columns represent values
- First line identifies the column, for example, "Purchase_Order_Amount_Local"
- Spreadsheet format is a common standard, the US Audit Data Standard (no global standard exists)
  https://www.aicpa.org/interestareas/frc/assuranceadvisoryservices/auditdatastandards.html

Purchase Orders



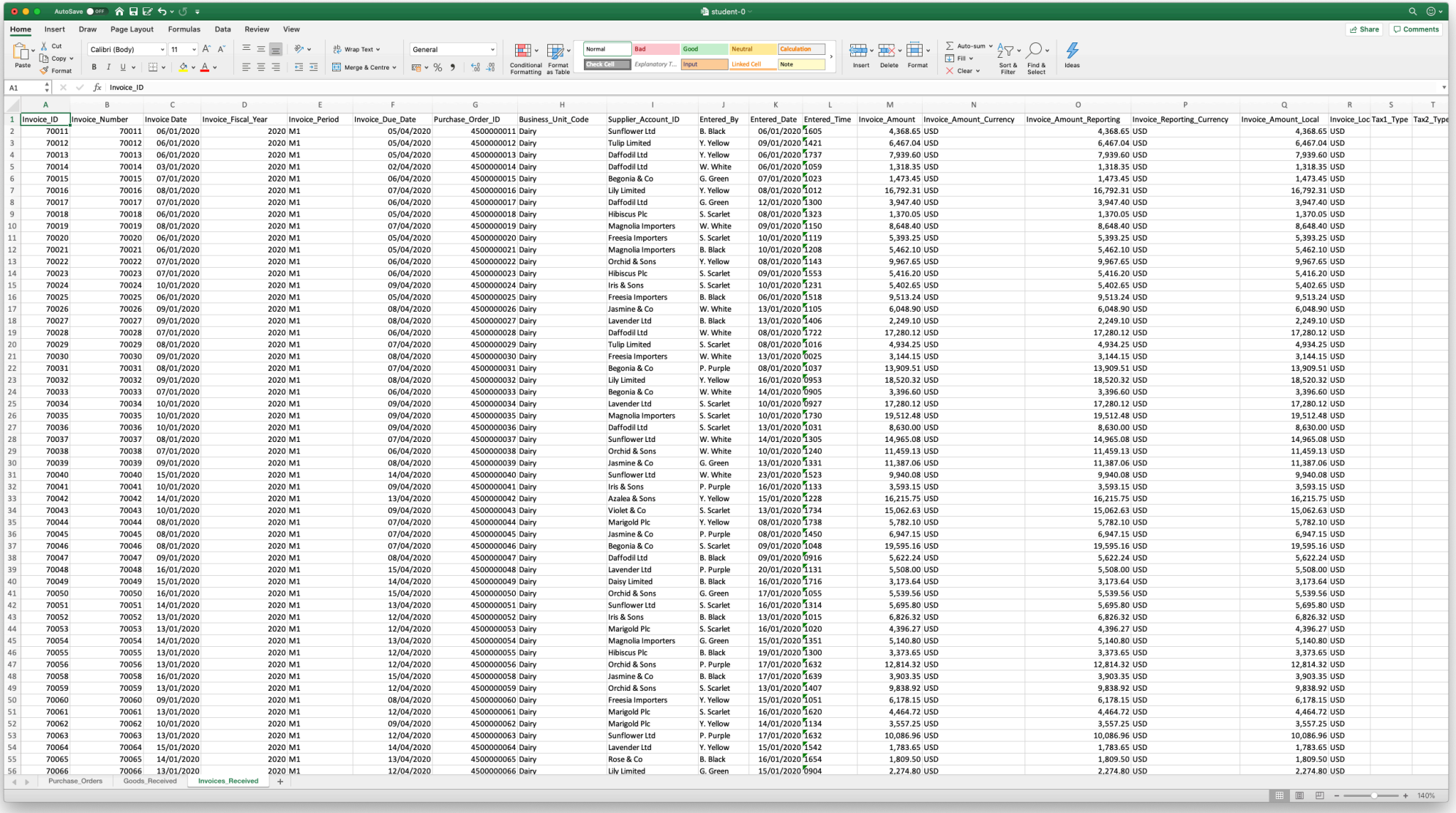
Purchase_Order_ID	Purchase_Order_Document_ID	Purchase_Order_Date	Purchase_Order_Fiscal_Year	Purchase_Order_Period	Business_Unit_Code	Supplier_Account_ID	Entered_By	Purchase_Order_Amount_Local	Purchase_Order_Local_Currency
4500000011	4500000011	02/01/2020	2020	M1	Dairy	Sunflower Ltd	Procurement	4,368.65	USD
4500000012	4500000012	02/01/2020	2020	M1	Dairy	Tulip Limited	Procurement	6,467.04	USD
4500000013	4500000013	02/01/2020	2020	M1	Dairy	Daffodil Ltd	Procurement	7,939.60	USD
4500000014	4500000014	02/01/2020	2020	M1	Dairy	Daffodil Ltd	Procurement	1,318.35	USD
4500000015	4500000015	03/01/2020	2020	M1	Dairy	Begonia & Co	Procurement	1,473.45	USD
4500000016	4500000016	03/01/2020	2020	M1	Dairy	Lily Limited	Procurement	16,792.31	USD
4500000017	4500000017	03/01/2020	2020	M1	Dairy	Daffodil Ltd	Procurement	3,947.40	USD
4500000018	4500000018	03/01/2020	2020	M1	Dairy	Hibiscus Plc	Procurement	1,370.05	USD
4500000019	4500000019	03/01/2020	2020	M1	Dairy	Magnolia Importers	Procurement	8,648.40	USD
4500000020	4500000020	03/01/2020	2020	M1	Dairy	Freesia Importers	Procurement	5,393.25	USD
4500000021	4500000021	03/01/2020	2020	M1	Dairy	Magnolia Importers	Procurement	5,462.10	USD
4500000022	4500000022	03/01/2020	2020	M1	Dairy	Orchid & Sons	Procurement	9,967.65	USD
4500000023	4500000023	03/01/2020	2020	M1	Dairy	Hibiscus Plc	Procurement	5,416.20	USD
4500000024	4500000024	06/01/2020	2020	M1	Dairy	Iris & Sons	Procurement	5,402.65	USD
4500000025	4500000025	06/01/2020	2020	M1	Dairy	Freesia Importers	Procurement	9,513.24	USD
4500000026	4500000026	06/01/2020	2020	M1	Dairy	Jasmine & Co	Procurement	6,048.90	USD
4500000027	4500000027	06/01/2020	2020	M1	Dairy	Lavender Ltd	Procurement	2,249.10	USD
4500000028	4500000028	06/01/2020	2020	M1	Dairy	Daffodil Ltd	Procurement	17,280.12	USD
4500000029	4500000029	06/01/2020	2020	M1	Dairy	Tulip Limited	Procurement	4,934.25	USD
4500000030	4500000030	06/01/2020	2020	M1	Dairy	Freesia Importers	Procurement	3,144.15	USD
4500000031	4500000031	06/01/2020	2020	M1	Dairy	Begonia & Co	Procurement	13,909.51	USD
4500000032	4500000032	07/01/2020	2020	M1	Dairy	Lily Limited	Procurement	18,520.32	USD
4500000033	4500000033	07/01/2020	2020	M1	Dairy	Begonia & Co	Procurement	3,396.60	USD
4500000034	4500000034	07/01/2020	2020	M1	Dairy	Lavender Ltd	Procurement	17,280.12	USD
4500000035	4500000035	07/01/2020	2020	M1	Dairy	Magnolia Importers	Procurement	19,512.48	USD
4500000036	4500000036	07/01/2020	2020	M1	Dairy	Daffodil Ltd	Procurement	8,630.00	USD
4500000037	4500000037	07/01/2020	2020	M1	Dairy	Sunflower Ltd	Procurement	14,965.08	USD
4500000038	4500000038	07/01/2020	2020	M1	Dairy	Orchid & Sons	Procurement	11,459.13	USD
4500000039	4500000039	07/01/2020	2020	M1	Dairy	Jasmine & Co	Procurement	11,387.06	USD
4500000040	4500000040	07/01/2020	2020	M1	Dairy	Sunflower Ltd	Procurement	9,940.08	USD
4500000041	4500000041	07/01/2020	2020	M1	Dairy	Iris & Sons	Procurement	3,593.15	USD
4500000042	4500000042	07/01/2020	2020	M1	Dairy	Azalea & Sons	Procurement	16,215.75	USD
4500000043	4500000043	08/01/2020	2020	M1	Dairy	Violet & Co	Procurement	15,062.63	USD
4500000044	4500000044	08/01/2020	2020	M1	Dairy	Marigold Plc	Procurement	5,782.10	USD
4500000045	4500000045	08/01/2020	2020	M1	Dairy	Jasmine & Co	Procurement	6,947.15	USD
4500000046	4500000046	08/01/2020	2020	M1	Dairy	Begonia & Co	Procurement	19,595.16	USD
4500000047	4500000047	08/01/2020	2020	M1	Dairy	Daffodil Ltd	Procurement	5,622.24	USD
4500000048	4500000048	08/01/2020	2020	M1	Dairy	Lavender Ltd	Procurement	5,508.00	USD
4500000049	4500000049	08/01/2020	2020	M1	Dairy	Daisy Limited	Procurement	3,173.64	USD
4500000050	4500000050	08/01/2020	2020	M1	Dairy	Orchid & Sons	Procurement	5,539.56	USD
4500000051	4500000051	08/01/2020	2020	M1	Dairy	Sunflower Ltd	Procurement	5,695.80	USD
4500000052	4500000052	08/01/2020	2020	M1	Dairy	Iris & Sons	Procurement	6,826.32	USD
4500000053	4500000053	09/01/2020	2020	M1	Dairy	Marigold Plc	Procurement	4,396.27	USD
4500000054	4500000054	09/01/2020	2020	M1	Dairy	Magnolia Importers	Procurement	5,140.80	USD
4500000055	4500000055	09/01/2020	2020	M1	Dairy	Hibiscus Plc	Procurement	3,373.65	USD
4500000056	4500000056	09/01/2020	2020	M1	Dairy	Orchid & Sons	Procurement	12,814.32	USD
4500000057	4500000057	09/01/2020	2020	M1	Dairy	Rose & Co	Procurement	4,131.00	USD
4500000058	4500000058	09/01/2020	2020	M1	Dairy	Jasmine & Co	Procurement	3,903.35	USD
4500000059	4500000059	09/01/2020	2020	M1	Dairy	Orchid & Sons	Procurement	9,838.92	USD
4500000060	4500000060	09/01/2020	2020	M1	Dairy	Freesia Importers	Procurement	6,178.15	USD

Goods Received



Receipt_ID	Receipt_Date	Receipt_Fiscal_Year	Receipt_Period	Receipt_Document_ID	Supplier_Account_ID	Business_Unit_Code	Purchase_Order_ID	Purchase_Order_Date	Entered_By	Receipt_Amount_Local	Receipt_Local_Currency	Purchase_Order_Amount_Local	Purchase_Order_Local_Currency
910064	08/01/2020	2020	M1	910064	Sunflower Ltd	Dairy	4500000011	02/01/2020	Warehouse	4,368.65	USD	4,368.65	USD
910065	02/01/2020	2020	M1	910065	Tulip Limited	Dairy	4500000012	02/01/2020	Warehouse	6,467.04	USD	6,467.04	USD
910066	06/01/2020	2020	M1	910066	Daffodil Ltd	Dairy	4500000013	02/01/2020	Warehouse	7,939.60	USD	7,939.60	USD
910067	06/01/2020	2020	M1	910067	Daffodil Ltd	Dairy	4500000014	02/01/2020	Warehouse	1,318.35	USD	1,318.35	USD
910068	06/01/2020	2020	M1	910068	Begonia & Co	Dairy	4500000015	03/01/2020	Warehouse	1,473.45	USD	1,473.45	USD
910069	07/01/2020	2020	M1	910069	Lily Limited	Dairy	4500000016	03/01/2020	Warehouse	16,792.31	USD	16,792.31	USD
910070	09/01/2020	2020	M1	910070	Daffodil Ltd	Dairy	4500000017	03/01/2020	Warehouse	3,947.40	USD	3,947.40	USD
910071	06/01/2020	2020	M1	910071	Hibiscus Plc	Dairy	4500000018	03/01/2020	Warehouse	1,370.05	USD	1,370.05	USD
910072	06/01/2020	2020	M1	910072	Magnolia Importers	Dairy	4500000019	03/01/2020	Warehouse	8,648.40	USD	8,648.40	USD
910073	08/01/2020	2020	M1	910073	Freesia Importers	Dairy	4500000020	03/01/2020	Warehouse	5,393.25	USD	5,393.25	USD
910074	06/01/2020	2020	M1	910074	Magnolia Importers	Dairy	4500000021	03/01/2020	Warehouse	5,462.10	USD	5,462.10	USD
910075	03/01/2020	2020	M1	910075	Orchid & Sons	Dairy	4500000022	03/01/2020	Warehouse	9,967.65	USD	9,967.65	USD
910076	06/01/2020	2020	M1	910076	Hibiscus Plc	Dairy	4500000023	03/01/2020	Warehouse	5,416.20	USD	5,416.20	USD
910077	07/01/2020	2020	M1	910077	Iris & Sons	Dairy	4500000024	06/01/2020	Warehouse	5,402.65	USD	5,402.65	USD
910078	09/01/2020	2020	M1	910078	Freesia Importers	Dairy	4500000025	06/01/2020	Warehouse	9,513.24	USD	9,513.24	USD
910079	10/01/2020	2020	M1	910079	Jasmine & Co	Dairy	4500000026	06/01/2020	Warehouse	6,048.90	USD	6,048.90	USD
910080	09/01/2020	2020	M1	910080	Lavender Ltd	Dairy	4500000027	06/01/2020	Warehouse	2,249.10	USD	2,249.10	USD
910081	08/01/2020	2020	M1	910081	Daffodil Ltd	Dairy	4500000028	06/01/2020	Warehouse	17,280.12	USD	17,280.12	USD
910082	09/01/2020	2020	M1	910082	Tulip Limited	Dairy	4500000029	06/01/2020	Warehouse	4,934.25	USD	4,934.25	USD
910083	06/01/2020	2020	M1	910083	Freesia Importers	Dairy	4500000030	06/01/2020	Warehouse	3,144.15	USD	3,144.15	USD
910084	07/01/2020	2020	M1	910084	Begonia & Co	Dairy	4500000031	06/01/2020	Warehouse	13,909.51	USD	13,909.51	USD
910085	14/01/2020	2020	M1	910085	Lily Limited	Dairy	4500000032	07/01/2020	Warehouse	18,520.32	USD	18,520.32	USD
910086	16/01/2020	2020	M1	910086	Begonia & Co	Dairy	4500000033	07/01/2020	Warehouse	3,396.60	USD	3,396.60	USD
910087	08/01/2020	2020	M1	910087	Lavender Ltd	Dairy	4500000034	07/01/2020	Warehouse	17,280.12	USD	17,280.12	USD
910088	14/01/2020	2020	M1	910088	Magnolia Importers	Dairy	4500000035	07/01/2020	Warehouse	19,512.48	USD	19,512.48	USD
910089	08/01/2020	2020	M1	910089	Daffodil Ltd	Dairy	4500000036	07/01/2020	Warehouse	8,630.00	USD	8,630.00	USD
910090	07/01/2020	2020	M1	910090	Sunflower Ltd	Dairy	4500000037	07/01/2020	Warehouse	14,965.08	USD	14,965.08	USD
910091	07/01/2020	2020	M1	910091	Orchid & Sons	Dairy	4500000038	07/01/2020	Warehouse	11,459.13	USD	11,459.13	USD
910092	10/01/2020	2020	M1	910092	Jasmine & Co	Dairy	4500000039	07/01/2020	Warehouse	11,387.06	USD	11,387.06	USD
910093	07/01/2020	2020	M1	910093	Sunflower Ltd	Dairy	4500000040	07/01/2020	Warehouse	9,940.08	USD	9,940.08	USD
910094	07/01/2020	2020	M1	910094	Iris & Sons	Dairy	4500000041	07/01/2020	Warehouse	3,593.15	USD	3,593.15	USD
910095	14/01/2020	2020	M1	910095	Azalea & Sons	Dairy	4500000042	07/01/2020	Warehouse	16,215.75	USD	16,215.75	USD
910096	15/01/2020	2020	M1	910096	Violet & Co	Dairy	4500000043	08/01/2020	Warehouse	15,062.63	USD	15,062.63	USD
910097	10/01/2020	2020	M1	910097	Marigold Plc	Dairy	4500000044	08/01/2020	Warehouse	5,782.10	USD	5,782.10	USD
910098	10/01/2020	2020	M1	910098	Jasmine & Co	Dairy	4500000045	08/01/2020	Warehouse	6,947.15	USD	6,947.15	USD
910099	10/01/2020	2020	M1	910099	Begonia & Co	Dairy	4500000046	08/01/2020	Warehouse	19,595.16	USD	19,595.16	USD
910100	15/01/2020	2020	M1	910100	Daffodil Ltd	Dairy	4500000047	08/01/2020	Warehouse	5,622.24	USD	5,622.24	USD
910101	15/01/2020	2020	M1	910101	Lavender Ltd	Dairy	4500000048	08/01/2020	Warehouse	5,508.00	USD	5,508.00	USD
910102	15/01/2020	2020	M1	910102	Daisy Limited	Dairy	4500000049	08/01/2020	Warehouse	3,173.64	USD	3,173.64	USD
910103	13/01/2020	2020	M1	910103	Orchid & Sons	Dairy	4500000050	08/01/2020	Warehouse	5,539.56	USD	5,539.56	USD
910104	16/01/2020	2020	M1	910104	Sunflower Ltd	Dairy	4500000051	08/01/2020	Warehouse	5,695.80	USD	5,695.80	USD
910105	15/01/2020	2020	M1	910105	Iris & Sons	Dairy	4500000052	08/01/2020	Warehouse	6,826.32	USD	6,826.32	USD
910106	16/01/2020	2020	M1	910106	Marigold Plc	Dairy	4500000053	09/01/2020	Warehouse	4,396.27	USD	4,396.27	USD
910107	09/01/2020	2020	M1	910107	Magnolia Importers	Dairy	4500000054	09/01/2020	Warehouse	5,140.80	USD	5,140.80	USD
910108	09/01/2020	2020	M1	910108	Hibiscus Plc	Dairy	4500000055	09/01/2020	Warehouse	3,373.65	USD	3,373.65	USD
910109	13/01/2020	2020	M1	910109	Orchid & Sons	Dairy	4500000056	09/01/2020	Warehouse	12,814.32	USD	12,814.32	USD
910110	13/01/2020	2020	M1	910110	Rose & Co	Dairy	4500000057	09/01/2020	Warehouse	4,131.00	USD	4,131.00	USD
910111	10/01/2020	2020	M1	910111	Jasmine & Co	Dairy	4500000058	09/01/2020	Warehouse	3,903.35	USD	3,903.35	USD
910112	09/01/2020	2020	M1	910112	Orchid & Sons	Dairy	4500000059	09/01/2020	Warehouse	9,838.92	USD	9,838.92	USD
910113	09/01/2020	2020	M1	910113	Freesia Importers	Dairy	4500000060	09/01/2020	Warehouse	6,178.15	USD	6,178.15	USD

Invoices Received



Invoice_ID	Invoice_Number	Invoice Date	Invoice_Fiscal_Year	Invoice_Period	Invoice_Due_Date	Purchase_Order_ID	Business_Unit_Code	Supplier_Account_ID	Entered_By	Entered_Date	Entered_Time	Invoice_Amount	Invoice_Amount_Currency	Invoice_Amount_Reporting	Invoice_Reporting_Currency	Invoice_Amount_Local	Invoice_Loc	Tax1_Type	Tax2_Type
70011	70011	06/01/2020	2020	M1	05/04/2020	4500000011	Dairy	Sunflower Ltd	B. Black	06/01/2020	1605	4,368.65	USD	4,368.65	USD	4,368.65	USD		
70012	70012	06/01/2020	2020	M1	05/04/2020	4500000012	Dairy	Tulip Limited	Y. Yellow	09/01/2020	1421	6,467.04	USD	6,467.04	USD	6,467.04	USD		
70013	70013	06/01/2020	2020	M1	05/04/2020	4500000013	Dairy	Daffodil Ltd	Y. Yellow	06/01/2020	1737	7,939.60	USD	7,939.60	USD	7,939.60	USD		
70014	70014	03/01/2020	2020	M1	02/04/2020	4500000014	Dairy	Daffodil Ltd	W. White	06/01/2020	1059	1,318.35	USD	1,318.35	USD	1,318.35	USD		
70015	70015	07/01/2020	2020	M1	06/04/2020	4500000015	Dairy	Begonia & Co	G. Green	07/01/2020	1023	1,473.45	USD	1,473.45	USD	1,473.45	USD		
70016	70016	08/01/2020	2020	M1	07/04/2020	4500000016	Dairy	Lily Limited	Y. Yellow	08/01/2020	1012	16,792.31	USD	16,792.31	USD	16,792.31	USD		
70017	70017	07/01/2020	2020	M1	06/04/2020	4500000017	Dairy	Daffodil Ltd	G. Green	12/01/2020	1300	3,947.40	USD	3,947.40	USD	3,947.40	USD		
70018	70018	06/01/2020	2020	M1	05/04/2020	4500000018	Dairy	Hibiscus Plc	S. Scarlet	08/01/2020	1323	1,370.05	USD	1,370.05	USD	1,370.05	USD		
70019	70019	08/01/2020	2020	M1	07/04/2020	4500000019	Dairy	Magnolia Importers	W. White	09/01/2020	1150	8,648.40	USD	8,648.40	USD	8,648.40	USD		
70020	70020	06/01/2020	2020	M1	05/04/2020	4500000020	Dairy	Freesia Importers	S. Scarlet	10/01/2020	1119	5,393.25	USD	5,393.25	USD	5,393.25	USD		
70021	70021	06/01/2020	2020	M1	05/04/2020	4500000021	Dairy	Magnolia Importers	B. Black	10/01/2020	1208	5,462.10	USD	5,462.10	USD	5,462.10	USD		
70022	70022	07/01/2020	2020	M1	06/04/2020	4500000022	Dairy	Orchid & Sons	Y. Yellow	08/01/2020	1143	9,967.65	USD	9,967.65	USD	9,967.65	USD		
70023	70023	07/01/2020	2020	M1	06/04/2020	4500000023	Dairy	Hibiscus Plc	S. Scarlet	09/01/2020	1553	5,416.20	USD	5,416.20	USD	5,416.20	USD		
70024	70024	10/01/2020	2020	M1	09/04/2020	4500000024	Dairy	Iris & Sons	S. Scarlet	10/01/2020	1231	5,402.65	USD	5,402.65	USD	5,402.65	USD		
70025	70025	06/01/2020	2020	M1	05/04/2020	4500000025	Dairy	Freesia Importers	B. Black	06/01/2020	1518	9,513.24	USD	9,513.24	USD	9,513.24	USD		
70026	70026	09/01/2020	2020	M1	08/04/2020	4500000026	Dairy	Jasmine & Co	W. White	13/01/2020	1105	6,048.90	USD	6,048.90	USD	6,048.90	USD		
70027	70027	09/01/2020	2020	M1	08/04/2020	4500000027	Dairy	Lavender Ltd	B. Black	13/01/2020	1406	2,249.10	USD	2,249.10	USD	2,249.10	USD		
70028	70028	07/01/2020	2020	M1	06/04/2020	4500000028	Dairy	Daffodil Ltd	W. White	08/01/2020	1722	17,280.12	USD	17,280.12	USD	17,280.12	USD		
70029	70029	08/01/2020	2020	M1	07/04/2020	4500000029	Dairy	Tulip Limited	S. Scarlet	08/01/2020	1016	4,934.25	USD	4,934.25	USD	4,934.25	USD		
70030	70030	09/01/2020	2020	M1	08/04/2020	4500000030	Dairy	Freesia Importers	W. White	13/01/2020	0025	3,144.15	USD	3,144.15	USD	3,144.15	USD		
70031	70031	08/01/2020	2020	M1	07/04/2020	4500000031	Dairy	Begonia & Co	P. Purple	08/01/2020	1037	13,909.51	USD	13,909.51	USD	13,909.51	USD		
70032	70032	09/01/2020	2020	M1	08/04/2020	4500000032	Dairy	Lily Limited	Y. Yellow	16/01/2020	0953	18,520.32	USD	18,520.32	USD	18,520.32	USD		
70033	70033	07/01/2020	2020	M1	06/04/2020	4500000033	Dairy	Begonia & Co	W. White	14/01/2020	0905	3,396.60	USD	3,396.60	USD	3,396.60	USD		
70034	70034	10/01/2020	2020	M1	09/04/2020	4500000034	Dairy	Lavender Ltd	S. Scarlet	10/01/2020	0927	17,280.12	USD	17,280.12	USD	17,280.12	USD		
70035	70035	10/01/2020	2020	M1	09/04/2020	4500000035	Dairy	Magnolia Importers	S. Scarlet	10/01/2020	1730	19,512.48	USD	19,512.48	USD	19,512.48	USD		
70036	70036	10/01/2020	2020	M1	09/04/2020	4500000036	Dairy	Daffodil Ltd	S. Scarlet	13/01/2020	1031	8,630.00	USD	8,630.00	USD	8,630.00	USD		
70037	70037	08/01/2020	2020	M1	07/04/2020	4500000037	Dairy	Sunflower Ltd	W. White	14/01/2020	1305	14,965.08	USD	14,965.08	USD	14,965.08	USD		
70038	70038	07/01/2020	2020	M1	06/04/2020	4500000038	Dairy	Orchid & Sons	W. White	10/01/2020	1240	11,459.13	USD	11,459.13	USD	11,459.13	USD		
70039	70039	09/01/2020	2020	M1	08/04/2020	4500000039	Dairy	Jasmine & Co	G. Green	13/01/2020	1331	11,387.06	USD	11,387.06	USD	11,387.06	USD		
70040	70040	15/01/2020	2020	M1	14/04/2020	4500000040	Dairy	Sunflower Ltd	W. White	23/01/2020	1523	9,940.08	USD	9,940.08	USD	9,940.08	USD		
70041	70041	10/01/2020	2020	M1	09/04/2020	4500000041	Dairy	Iris & Sons	P. Purple	16/01/2020	1133	3,593.15	USD	3,593.15	USD	3,593.15	USD		
70042	70042	14/01/2020	2020	M1	13/04/2020	4500000042	Dairy	Azalea & Sons	Y. Yellow	15/01/2020	1228	16,215.75	USD	16,215.75	USD	16,215.75	USD		
70043	70043	10/01/2020	2020	M1	09/04/2020	4500000043	Dairy	Violet & Co	S. Scarlet	13/01/2020	1734	15,062.63	USD	15,062.63	USD	15,062.63	USD		
70044	70044	08/01/2020	2020	M1	07/04/2020	4500000044	Dairy	Marigold Plc	Y. Yellow	08/01/2020	1738	5,782.10	USD	5,782.10	USD	5,782.10	USD		
70045	70045	08/01/2020	2020	M1	07/04/2020	4500000045	Dairy	Jasmine & Co	P. Purple	08/01/2020	1450	6,947.15	USD	6,947.15	USD	6,947.15	USD		
70046	70046	08/01/2020	2020	M1	07/04/2020	4500000046	Dairy	Begonia & Co	S. Scarlet	09/01/2020	1048	19,595.16	USD	19,595.16	USD	19,595.16	USD		
70047	70047	09/01/2020	2020	M1	08/04/2020	4500000047	Dairy	Daffodil Ltd	B. Black	09/01/2020	0916	5,622.24	USD	5,622.24	USD	5,622.24	USD		
70048	70048	16/01/2020	2020	M1	15/04/2020	4500000048	Dairy	Lavender Ltd	P. Purple	20/01/2020	1131	5,508.00	USD	5,508.00	USD	5,508.00	USD		
70049	70049	15/01/2020	2020	M1	14/04/2020	4500000049	Dairy	Daisy Limited	B. Black	16/01/2020	1716	3,173.64	USD	3,173.64	USD	3,173.64	USD		
70050	70050	16/01/2020	2020	M1	15/04/2020	4500000050	Dairy	Orchid & Sons	G. Green	17/01/2020	1055	5,539.56	USD	5,539.56	USD	5,539.56	USD		
70051	70051	14/01/2020	2020	M1	13/04/2020	4500000051	Dairy	Sunflower Ltd	S. Scarlet	16/01/2020	1314	5,695.80	USD	5,695.80	USD	5,695.80	USD		
70052	70052	13/01/2020	2020	M1	12/04/2020	4500000052	Dairy	Iris & Sons	B. Black	13/01/2020	1015	6,826.32	USD	6,826.32	USD	6,826.32	USD		
70053	70053	13/01/2020	2020	M1	12/04/2020	4500000053	Dairy	Marigold Plc	S. Scarlet	16/01/2020	1020	4,396.27	USD	4,396.27	USD	4,396.27	USD		
70054	70054	14/01/2020	2020	M1	13/04/2020	4500000054	Dairy	Magnolia Importers	G. Green	15/01/2020	1351	5,140.80	USD	5,140.80	USD	5,140.80	USD		
70055	70055	13/01/2020	2020	M1	12/04/2020	4500000055	Dairy	Hibiscus Plc	B. Black	19/01/2020	1300	3,373.65	USD	3,373.65	USD	3,373.65	USD		
70056	70056	13/01/2020	2020	M1	12/04/2020	4500000056	Dairy	Orchid & Sons	P. Purple	17/01/2020	1632	12,814.32	USD	12,814.32	USD	12,814.32	USD		
70058	70058	16/01/2020	2020	M1	15/04/2020	4500000058	Dairy	Jasmine & Co	B. Black	17/01/2020	1639	3,903.35	USD	3,903.35	USD	3,903.35	USD		
70059	70059	13/01/2020	2020	M1	12/04/2020	4500000059	Dairy	Orchid & Sons	S. Scarlet	13/01/2020	1407	9,838.92	USD	9,838.92	USD	9,838.92	USD		
70060	70060	09/01/2020	2020	M1	08/04/2020	4500000060	Dairy	Freesia Importers	Y. Yellow	15/01/2020	1051	6,178.15	USD	6,178.15	USD	6,178.15	USD		
70061	70061	13/01/2020	2020	M1	12/04/2020	4500000061	Dairy	Marigold Plc	S. Scarlet	16/01/2020	1620	4,464.72	USD	4,464.72	USD	4,464.72	USD		
70062	70062	10/01/2020	2020	M1	09/04/2020	4500000062	Dairy	Marigold Plc	Y. Yellow	14/01/2020	1134	3,557.25	USD	3,557.25	USD	3,557.25	USD		
70063	70063	13/01/2020	2020	M1	12/04/2020	4500000063	Dairy	Sunflower Ltd	P. Purple	17/01/2020	1632	10,086.96	USD	10,086.96	USD	10,086.96	USD		
70064	70064	15/01/2020	2020	M1	14/04/2020	4500000064	Dairy	Lavender Ltd	Y. Yellow	15/01/2020	1542	1,783.65	USD	1,783.65	USD	1,783.65	USD		
70065	70065	14/01/2020	2020	M1	13/04/2020	4500000065	Dairy	Rose & Co	B. Black	16/01/2020	1654	1,809.50	USD	1,809.50	USD	1,809.50	USD		
70066	70066	13/01/2020	2020	M1	12/04/2020	4500000066	Dairy	Lily Limited	G. Green	15/01/2020	0904	2,274.80	USD	2,274.80	USD	2,274.80	USD		

Examine invoices

On the invoice worksheet, identify the first invoice:

- Invoice_ID (70011)
- Invoice_Amount_Local (this is the amount in local currency)
- Purchase_Order_ID (first one is 4500000011)

On the purchase order worksheet, identify the corresponding purchase order

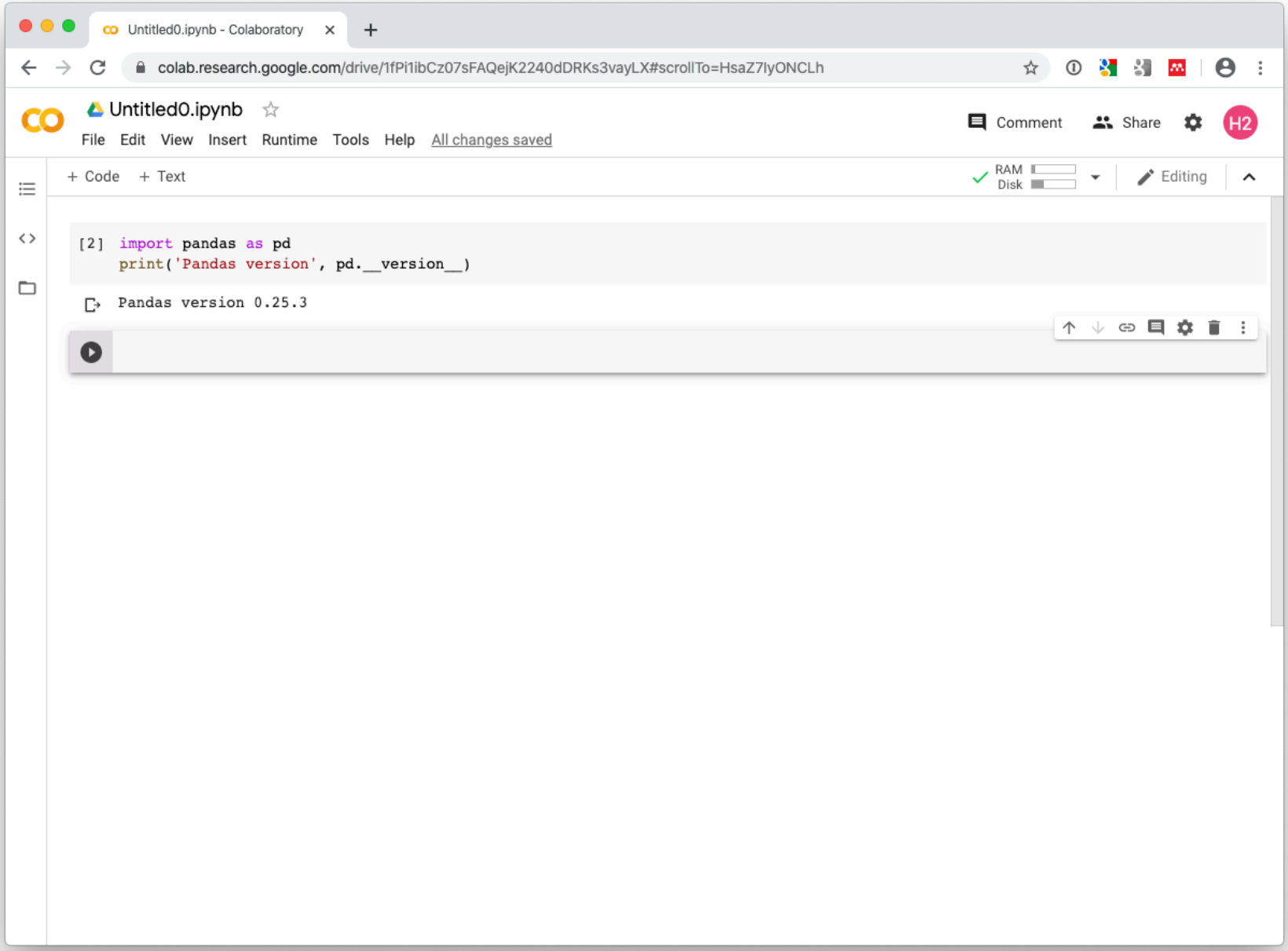
- Purchase_Order_ID (4500000011)
- Purchase_Order_Amount_Local

The amounts should be the same. Are they?

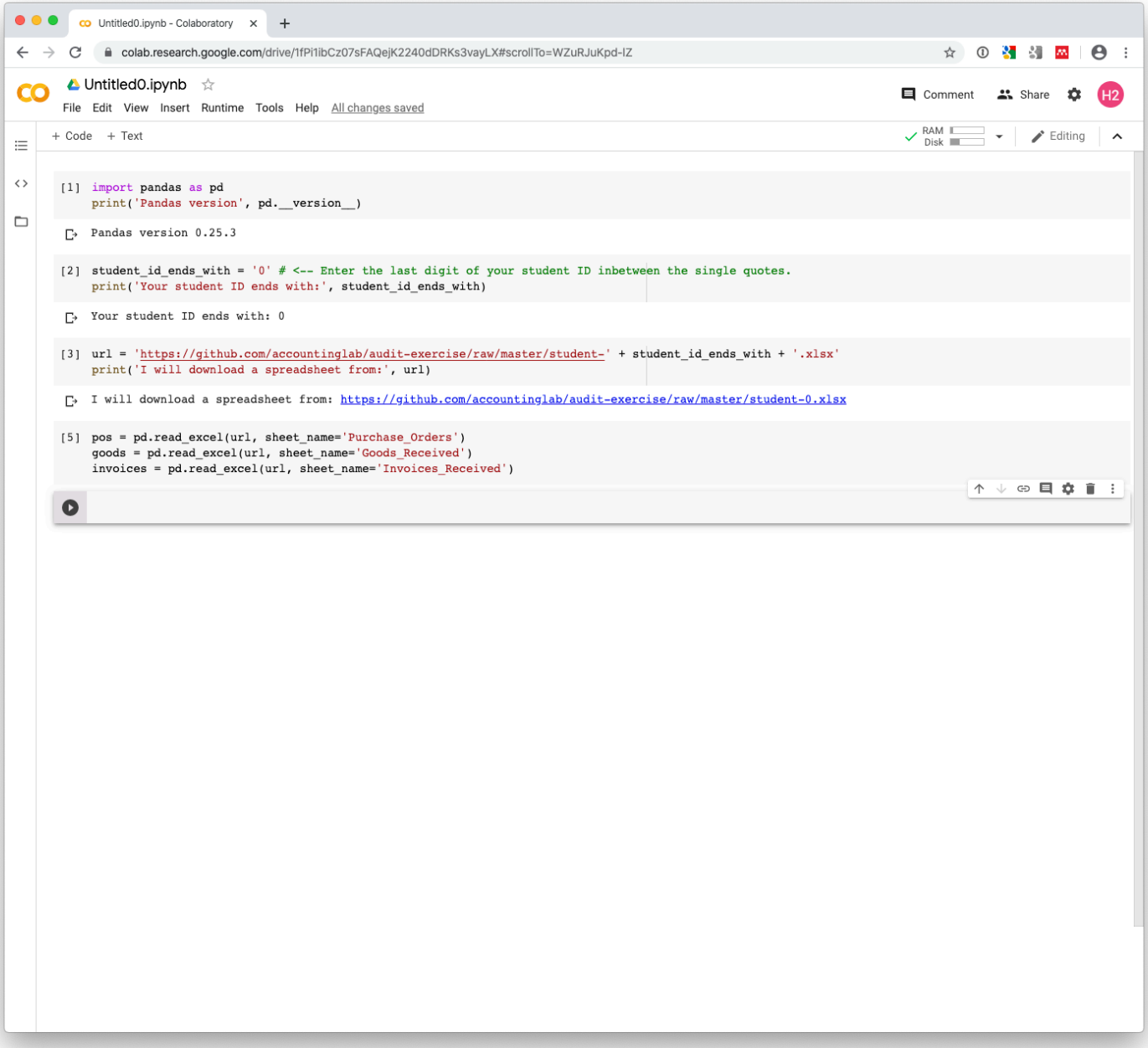
Python

- Manually performing the three-way match (checking purchase order, goods receipt, and invoice) is tedious and time-consuming
- With 11 lines of code in Python, we can achieve the same thing, and check 1000 documents in seconds.
- Let's go...

Import Pandas library



Import spreadsheet



View sample rows in Python

```
[6] pos.sample(n=5)
```

od	Business_Unit_Code	Supplier_Account_ID	Entered_By	Purchase_Order_Amount_Local	Purchase_Order_Local_Curren
M2	Dairy	Violet & Co	Procurement	1835.35	U
M4	Dairy	Lavender Ltd	Procurement	1285.20	U
M1	Dairy	Lavender Ltd	Procurement	16287.82	U
M5	Dairy	Orchid & Sons	Procurement	5909.74	U
M1	Dairy	Iris & Sons	Procurement	6531.72	U

```
[7] goods.sample(n=5)
```

_Account_ID	Business_Unit_Code	Purchase_Order_ID	Purchase_Order_Date	Entered_By	Receipt_Amount_Local	Receip
Azalea & Sons	Dairy	4500000067	2020-01-10	Warehouse	1887.05	
Iris & Sons	Dairy	4500000297	2020-02-13	Warehouse	1499.30	
Hibiscus Plc	Dairy	4500000782	2020-04-24	Warehouse	5645.70	
nolia Importers	Dairy	4500000438	2020-03-05	Warehouse	3465.45	
Iris & Sons	Dairy	4500000778	2020-04-24	Warehouse	11796.36	

```
[8] invoices.sample(n=5)
```

	Invoice_ID	Invoice_Number	Invoice Date	Invoice_Fiscal_Year	Invoice_Period	Invoice_Due_Date	Purchase_Order_
160	70174	70174	2020-01-27	2020	M1	2020-04-26	45000001
351	70368	70368	2020-02-27	2020	M2	2020-05-27	45000003
130	70144	70144	2020-01-22	2020	M1	2020-04-21	45000001
963	70988	70988	2020-05-26	2020	M5	2020-08-24	45000009
119	70133	70133	2020-01-21	2020	M1	2020-04-20	45000001

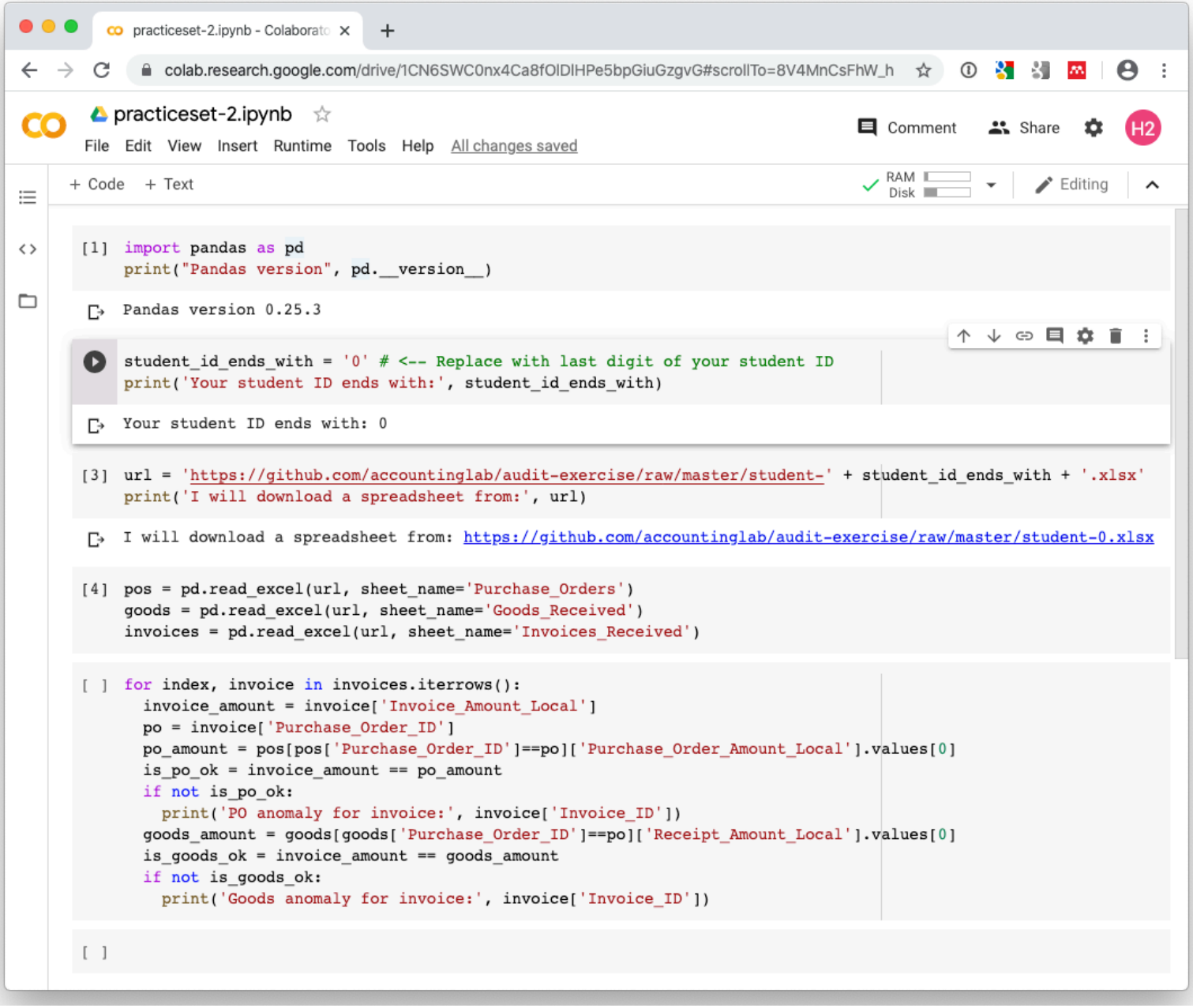
Loop through invoices

```
[ ] pos = pd.read_excel(url, sheet_name='Purchase_Orders')
    goods = pd.read_excel(url, sheet_name='Goods_Received')
    invoices = pd.read_excel(url, sheet_name='Invoices_Received')
```

```
[ ] for index, invoice in invoices.iterrows():
      invoice_id = invoice['Invoice_ID']
      invoice_amount = invoice['Invoice_Amount_Local']
      po = invoice['Purchase_Order_ID']
      po_amount = pos[pos['Purchase_Order_ID']==po]['Purchase_Order_Amount_Local'].values[0]
      goods_amount = goods[goods['Purchase_Order_ID']==po]['Receipt_Amount_Local'].values[0]
      print(invoice_id, 'Purchased:', po_amount, 'Received:', goods_amount, 'Invoiced:', invoice_amount)
```

```
70011 Purchased: 4368.65 Received: 4368.65 Invoiced: 4368.65
70012 Purchased: 6467.04 Received: 6467.04 Invoiced: 6467.04
70013 Purchased: 7939.6 Received: 7939.6 Invoiced: 7939.6
70014 Purchased: 1318.35 Received: 1318.35 Invoiced: 1318.35
70015 Purchased: 1473.45 Received: 1473.45 Invoiced: 1473.45
70016 Purchased: 16792.31 Received: 16792.31 Invoiced: 16792.31
70017 Purchased: 3947.4 Received: 3947.4 Invoiced: 3947.4
70018 Purchased: 1370.05 Received: 1370.05 Invoiced: 1370.05
70019 Purchased: 8648.4 Received: 8648.4 Invoiced: 8648.4
70020 Purchased: 5393.25 Received: 5393.25 Invoiced: 5393.25
```

The final routine



Found an anomaly, now what?

If all goes well, Python will uncover one or more suspect invoices

The routine will only print the suspect invoice ID

You need to look back into the spreadsheet to see what the problem was with the invoice.

For example

- The suspect invoice ID is 70044
- You look up the invoice in the spreadsheet, and you note down the amount, let's assume it was £3,557.25.
- You also note the Purchase Order ID.

- With the purchase order ID, you look up the purchase order amount in the purchase order worksheet, and the goods receipt amount in the goods received amount. You notice these amounts are £1,557.25.

- You conclude: you were over-invoiced by £2000.

Assessment

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Try it out!

- Use Practice Set 1 to help you understand the basics of Python
- Use Practice Set 2 to help you code the three-way match
- Use the Assessment Form to complete your exercise and submit
- All files are on https://github.com/accountinglab/audit-exercise

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