



THE UNIVERSITY *of* EDINBURGH  
School of Mathematics

# Exam marking online

**Dr George Kinnear**

G.Kinnear@ed.ac.uk

 @georgekinnear

**Dr Steven O'Hagan**

s.ohagan@ed.ac.uk

# Overview

- Context
- Guidance for students
- Marking process
- Plans for 2020/21



# Context

- Year 1 and Year 2 exams cancelled
- All others online
  - Open-book
  - Taken at a fixed time
  - Usual duration + 1 hour for submission
  - No-detriment policy



# Guidance for students



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# Writing clear instructions

- Initial draft tested by colleagues and improved
- Ran a 'dummy exam' for all students
- Provided feedback against a list of criteria



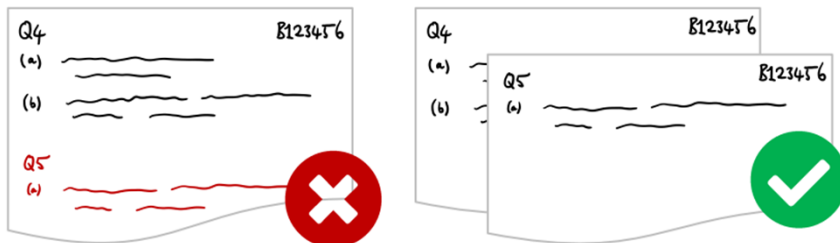
# Writing clear instructions

## Step 2: Write your work

At the **top of each page**, write the **question number** at the top left, and **your exam number** at the top right:



Start your answer to each question on a fresh sheet of paper.



Points: 0.11 (11.00%)

You put your Exam Number correctly on the top right of each sheet.

Points: 0 (0.00%)

Please put your Exam Number on the top right of EACH sheet.

Points: 0.11 (11.00%)

You correctly left out your student number.

Points: 0 (0.00%)

Please DO NOT include your student number - use your Exam Number only.

Points: 0.11 (11.00%)

The questions numbers are put on the top left of each page correctly.

Points: 0 (0.00%)

Please put the corresponding question number on the top left of EACH sheet.

Points: 0.11 (11.00%)

Points: 0 (0.00%)



# Submission

- Students allowed unlimited submissions for each exam
- Backup Microsoft Form in case of problems with Blackboard submission



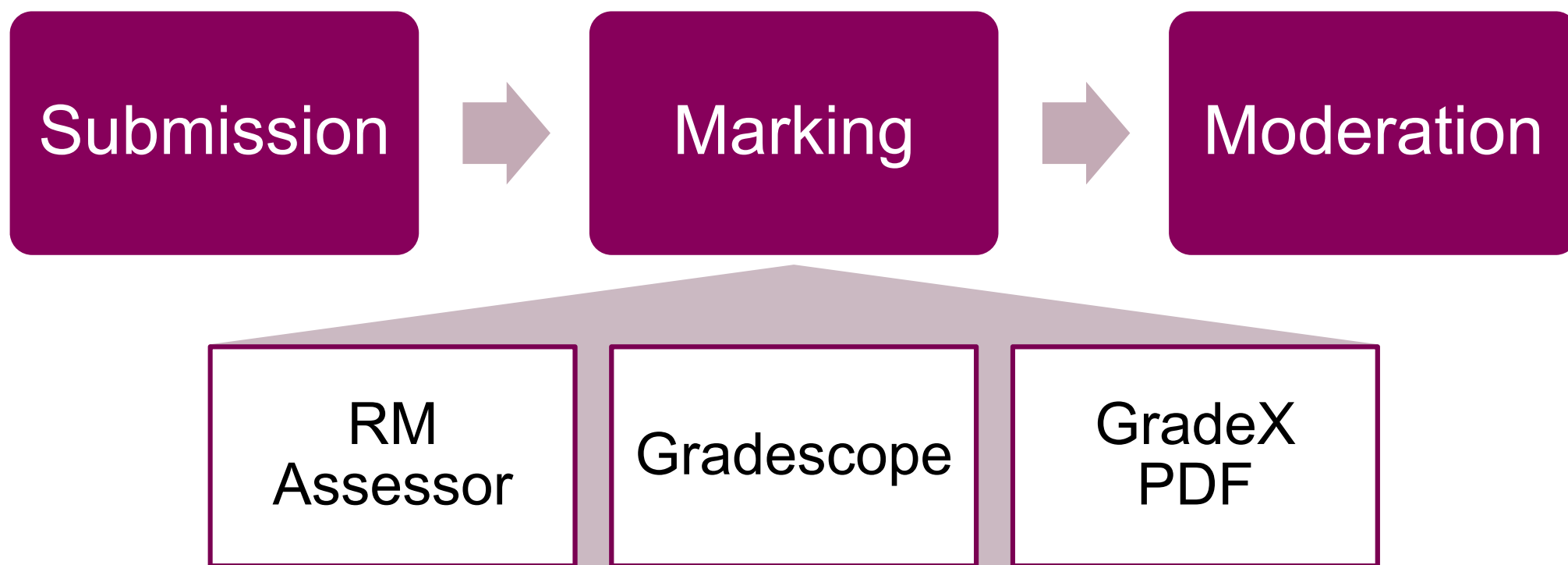
# Marking process



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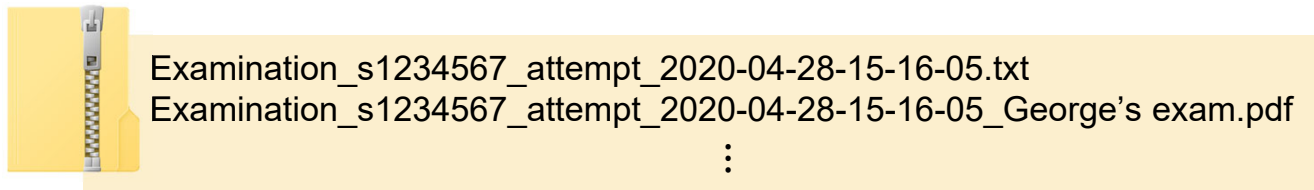
# Marking workflow



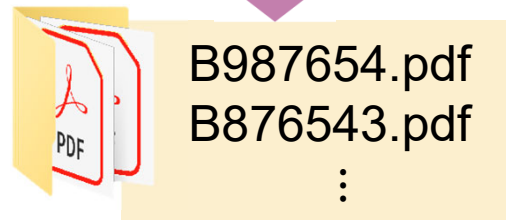
# Submission



- Download all attempts as .zip
- Students are not anonymous



	A	B	C
1	UUN	Exam Number	Extra Time
2	S1234567	B987654	60
3	S2345678	B876543	



# Mopping up

- Assemble single PDFs (e.g. from uploaded JPEGs)
- Check the backup submissions form
  - 72 submissions in total



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## School of Mathematics backup exam submission

Use this route to submit your solutions if and only if you are unable to do so through the course's Learn page provided the submission deadline has not passed.

We are aware that some students may not be receiving submission confirmation emails from Learn. This does not mean that your submission has not been received. You can check that your submission has been uploaded within Learn while the submission box is still open. If you think your submission has not worked then you may use this form.

Hi George, when you submit this form, the owner will be able to see your name and email address.

\* Required

1. Examination \*

Select your answer

2. Your solutions (Non-anonymous question ☺) \*

Upload file

File number limit: 1 Single file size limit: 100MB Allowed file types: PDF

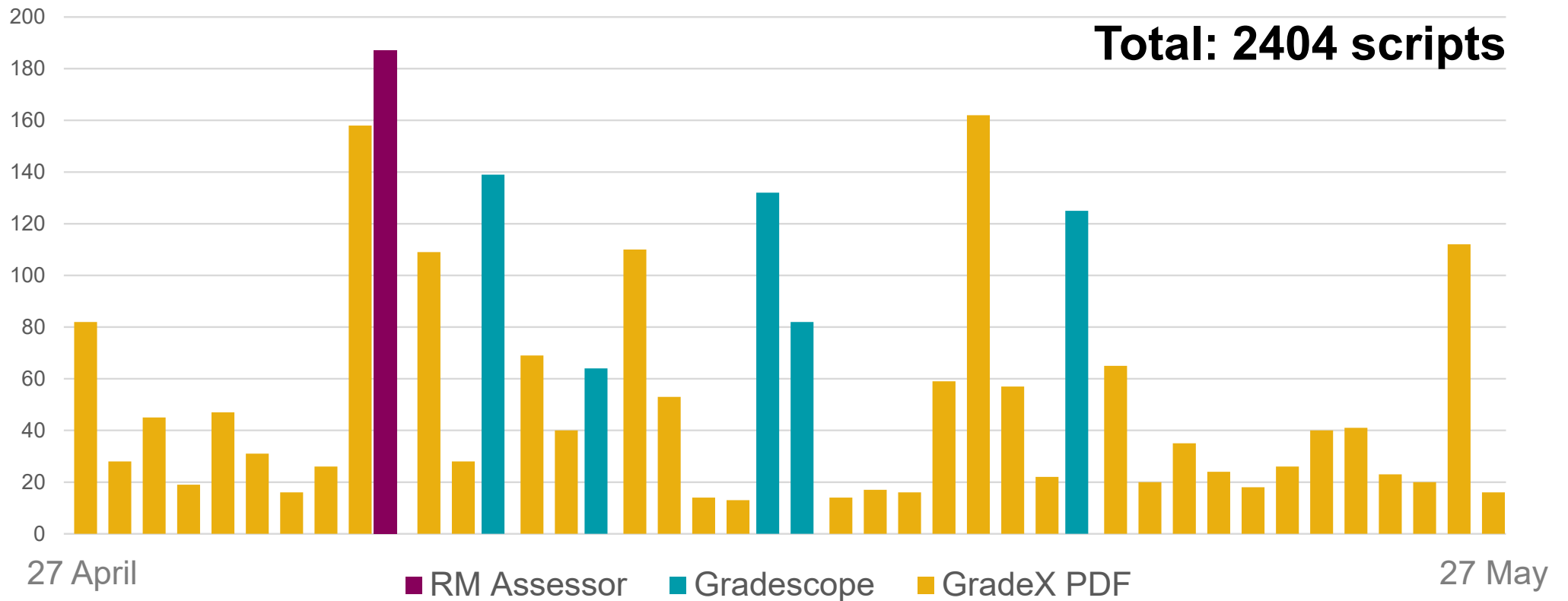
3. The file you upload here will only be looked at if you have not submitted a file in Learn AND you submit before your submission deadline. \*

I understand

Send me an email receipt of my responses

Submit

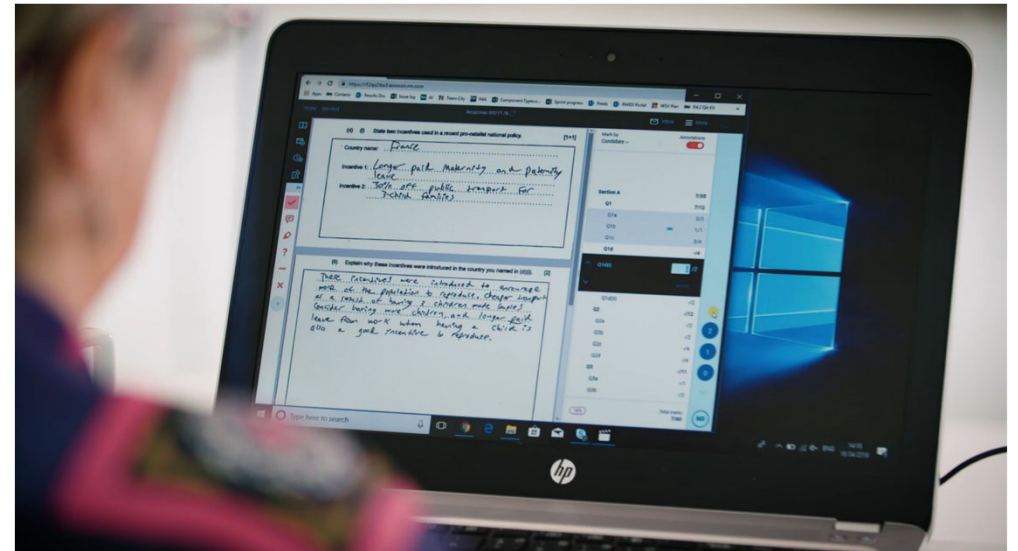
# Marking overview



# 1

# RM Assessor

- Used for high-stakes exams, e.g. IB, SQA
- “Proof of concept” for single course, with 180 scripts



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<https://rmresults.com/digital-assessment-solutions/rmassessor>

1

# RM Assessor

Zoning



Marking



Checking

- Marking up locations of question parts
- PhD students, took 6 hours for 180 scripts
- Q1 split between 2 PhD students (10 example generation items)
- Q2-4 marked by lecturer
- Lecturer review of Q1 marking



# 2

# Gradescope

- Split up exams by question
- Grade using rubrics

Name: \_\_\_\_\_ Student ID: \_\_\_\_\_

Introduction to Gradescope Fall 2014 Midterm

**Q1. Calculus**

Q1.1 [3pt] What is the integral of  $x$ ?

Q1.2 [3pt] What is the derivative of  $\cos x$ ?

Q2. [2pt] United States Geography

1.  $f'(x) = 30x^4 + 132x^3 - 90x^2$   
 $(6x^2(5x^2 + 22x - 15))$   
 $= 6x^2(5x^2 + 22x - 15)$   
 $= 6x^2(5x - 3)(x + 5)$

2.  $\frac{d}{dx} e^{2x} \sin(5x)$   
 $= 2e^{2x} \sin(5x) + 5e^{2x} \cos(5x)$



## Exam / Quiz

Instructors administer an assessment then collect and scan student work. Students answer each question in designated regions.

## Homework / Problem Set

Instructors specify a window of time that students can submit their work. Students upload their work via their phone or computer.

# 2

## Gradescope

Upload &  
Zoning



Marking



Checking

- Uploaded by Colin Rundel, automated using R
- PhD students took about an hour per 20 scripts
- Lecturer develops rubric
- Marking team applies the rubric
- Lecturer review of marking





# 2

# Gradescope

## Exam | Assign Questions and Pages

SUBMITTED AT: APRIL 15, 9:52 AM

Select questions and pages to indicate where your responses are located. Use **esc** to deselect all items and hold

**shift** to select multiple questions.

### Question Outline

Select a question or a page.

TITLE	POINTS
1 Q1	25.0 pts
<b>P1 x</b>	
2 Q2	25.0 pts
2.1 2a	7.0 pts
<b>P2 x</b>	
2.2 2b	6.0 pts
2.3 2c	7.0 pts
2.4 2d	5.0 pts
3 Q3	25.0 pts
3.1 3a	7.0 pts
<b>P3 x</b>	
3.2 3b	4.0 pts
3.3 3c	7.0 pts
2.4 2d	7.0 pts

**PAA - Hand-in Week 2/3** George Kinnear

**Problem 1**

1.  $A = \{(-1)^n : n \in \mathbb{N}\}$

$$(-1)^n = \begin{cases} 1 & \text{for even } n \\ -1 & \text{for odd } n \end{cases}$$

Thus  $A = \{-1, 1\}$ .

Clearly,  $\max A = 1$  and  $\sup A = 1$ , while  $\min A = -1 = \inf A$ .

2.  $A = \{\frac{1}{n} : n \in \mathbb{N}\} = \{1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \dots\}$

- $\max A = 1$ , since  $\frac{1}{n} > 1 \Leftrightarrow n < 1$  which is impossible with  $n \in \mathbb{N}$ .
- $\min A$  does not exist.
  - Suppose  $\min A = \frac{1}{k}$  for some  $k \in \mathbb{N}$ .
  - Clearly,  $\frac{1}{k+1} < \frac{1}{k}$  so  $\frac{1}{k}$  cannot be  $\min A$ .
- $\sup A = 1$ . We have already seen that  $\max A = 1$ , and  $\sup A = 1$  therefore follows by Proposition 1.5
- $\inf A = 0$ 
  - i)  $0$  is a lower bound for  $A$ , since  $\frac{1}{n} > 0$  for all  $n \in \mathbb{N}$
  - ii) there is no greater lower bound for  $A$ .
    - No  $y > 0$  can be a lower bound since for  $n > \frac{1}{y}$  we have  $\frac{1}{n} < y$ .

**Problem 6**

1. For  $\epsilon > 0$ , let  $n$  be the smallest natural number  $> \frac{1}{\epsilon} + 1$ .

**3.  $A = \{x \in \mathbb{R} : x \text{ is rational and } 0 \leq x < 1\}$**

- $\min A = 0$   
Clearly  $0 \in A$ , and there are no elements of  $A$  smaller than  $0$ .
- $\inf A = 0$   
This follows from the equivalent to Proposition 1.5 (i.e.  $\max A = a \Rightarrow \inf A = a$ ).
- $\max A$  does not exist  
Suppose  $\max A = p$  for some  $p \in A$ . Clearly  $p < 1$ .  
Now consider  $q = \frac{1}{2}p + \frac{1}{2} = p + \frac{1-p}{2}$ .  
Clearly  $q > p$  (since  $1-p > 0$ ), and we also have  $q \in A$  (since  $q$  is rational, and  $q < 1$  since  $p < 1$ ).  
Therefore there can be no maximal element of  $A$ .
- $\sup A = 1$ 
  - i)  $1$  is an upper bound; this is clear from the definition of  $A$  (" $0 \leq x < 1$ ").
  - ii) there can be no smaller upper bound, since for  $y < 1$  we can choose  $p > \frac{y}{1-y}$ , and  $\frac{p}{p+1} \in A$ .  
Also  $p > \frac{y}{1-y} \Leftrightarrow \frac{p}{p+1} > y$  so there is an element of  $A$  bigger than any  $y < 1$ .

2. Suppose  $b_n = \cos n\pi$  converges to some limit  $b \in \mathbb{R}$ .

By the definition of convergence, for  $\epsilon = \frac{1}{2}$  there exists



Zoning

# 2

# Gradescope

## Introduction to Gradescope

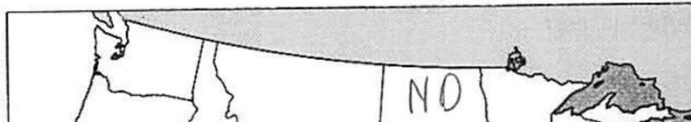
### Q1. Calculus

Q1.1 [3pt] What is the integral of x?

$$\frac{1}{2}x^2 + C$$

### Q2. [2pt] United States Geography

Mark North Dakota and South Dakota on the map below.



1.1: Integral ▾

10 OF 10 GRADED

TOTAL POINTS  
**1.5 / 3.0 pts**

- 1 **-0.0**  
Correct
- 2 **-1.5**  
missing +C
- 3 **+2.0**  
Bonus points
- 4 **-1.5**  
x^2 (no /2)
- 5 **-3.0**  
Blank

+ Add Rubric Item

⬇ Import...

SUBMISSION SPECIFIC ADJUSTMENTS

## Grading Dashboard

QUESTION	POINTS	PROGRESS	GRADED BY
1: Q1	25.0	<div style="width: 50%;"></div> 50%	GK
2: Q2	25.0		
2.1: 2a	7.0	<div style="width: 100%;"></div> 100%	GK
2.2: 2b	6.0	<div style="width: 0%;"></div> 0%	
2.3: 2c	7.0	<div style="width: 0%;"></div> 0%	
2.4: 2d	5.0	<div style="width: 0%;"></div> 0%	



Submission: 1 of 10

◀ Previous Ungraded

◀◀ Previous

Next ▶▶

Next Ungraded ▶

Marking

# 2

## Gradescope

TOTAL POINTS  
**1.0 / 4.0 pts** \* Rubric Settings

Collapse View ^

- 1 **-0.0**  
Correct.
- 2 **-1.0**  
Did not mention or prove  $d(f,g) \geq 0$ .
- 3 **-1.0**  
Proof that  $d(f,g)=0$  iff  $f=g$  is not correct or missing. For example, you may have proven  $d(f,g)=0$  implies  $f=g$  but without mentioning the fact that a nonnegative continuous function with integral zero must be zero. (Note that it is possible for the integral of  $|f-g|$  to be zero if it is only assumed  $f$  and  $g$  are Riemann integrable, so it is necessary to mention continuity.) You may have also not mentioned continuity but said "by a workshop problem" without specifying which.
- 4 **-1.0**  
Proof of symmetry is incorrect or missing.
- 5 **-1.0**  
Proof of triangle inequality is incorrect or missing.

- Rubric using negative marking
- Can be tweaked during marking

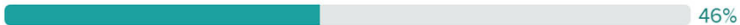
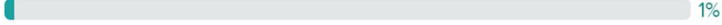

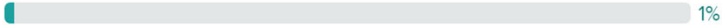
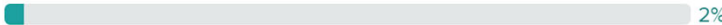
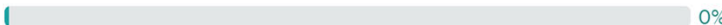
Marking



## 2

# Gradescope

MINIMUM	MEDIAN	MAXIMUM	MEAN	STD DEV
<b>0.0</b>	<b>3.0</b>	<b>4.0</b>	<b>3.33</b>	<b>0.78</b>

RUBRIC	POINTS	PERCENTAGE OF STUDENTS
Correct.	+ 0.0	 46%
Did not mention or prove $d(f,g) \geq 0$ .	- 1.0	 1%
Proof that $d(f,g)=0$ iff $f=g$ is not correct or missing. For example, you may have proven $d(f,g)=0$ implies $f=g$ but without mentioning the fact that the a nonnegative continuous function with integral zero must be zero. (Note that it is possible for the integral of $ f-g $ to be zero if it is only assumed $f$ and $g$ are Riemann integrable, so it is necessary to mention continuity.) You may have also not mentioned continuity but said "by a workshop problem" without specifying which.	- 1.0	 50%
Proof of symmetry is incorrect or missing.	- 1.0	 1%
Proof of triangle inequality is incorrect or missing.	- 1.0	 2%
No attempt or insufficient progress.	- 4.0	 0%

Checking

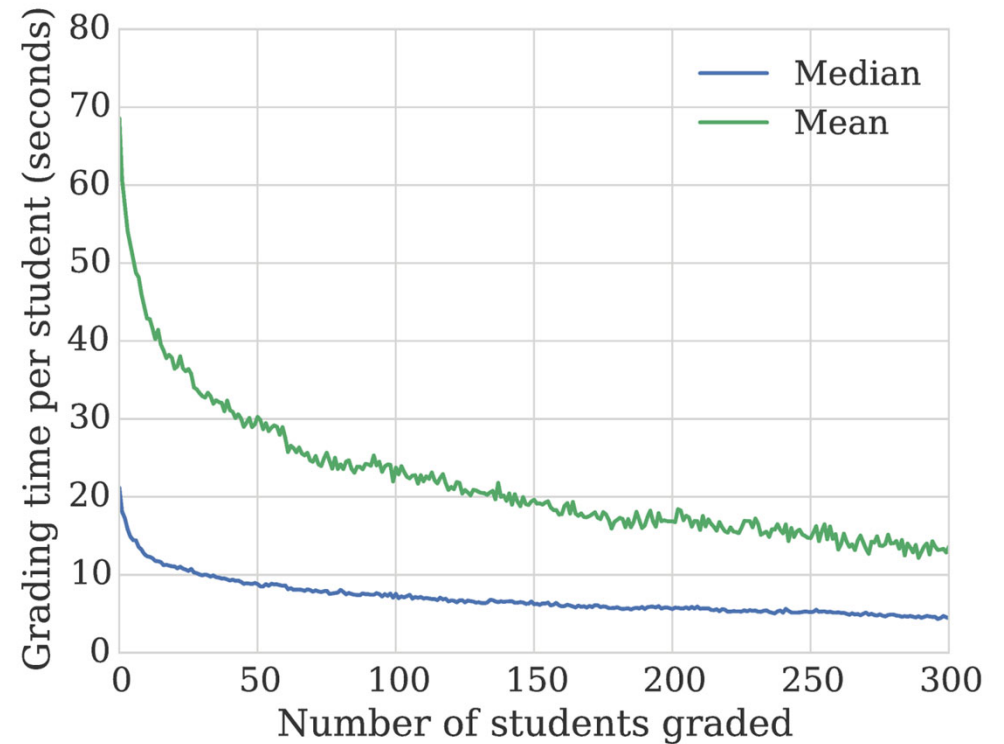


# 2

## Gradescope

Positive feedback from markers:

- Rubrics easy to use
- Fast



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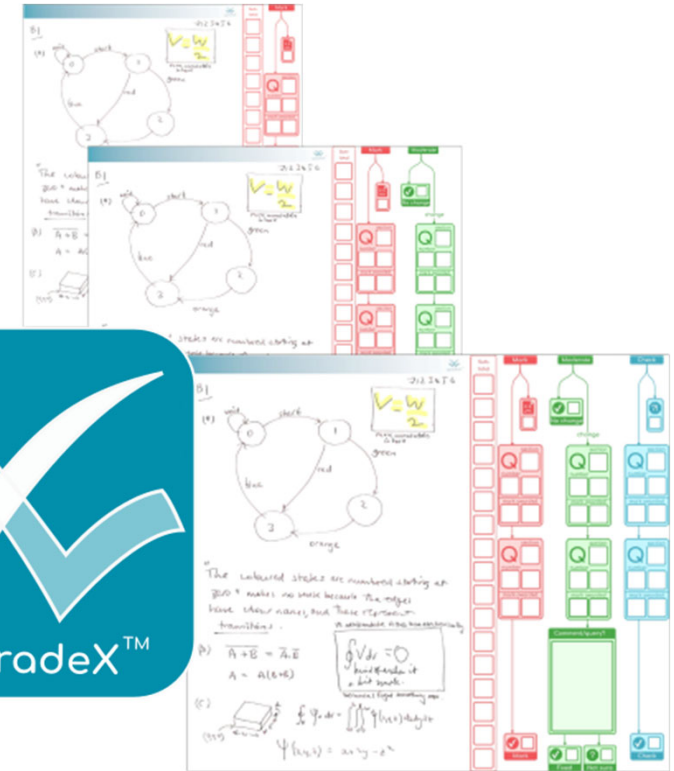
Singh, A., Karayev, S., Gutowski, K., & Abbeel, P. (2017). Gradescope: a Fast, Flexible, and Fair System for Scalable Assessment of Handwritten Work. <https://doi.org/10.1145/3051457.3051466>

# 3

# GradeX PDF

- Adding forms to the student PDFs
- Marks read out of the PDF into a spreadsheet
- Rapid development by Tim Drysdale

<https://github.com/timdrysdale>



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<https://pdf.gradex.io/>

# 3

# GradeX PDF

## Our version of the process:

Handwritten mathematical work on lined paper. The student ID B090637 is visible at the top right. The work includes:

(1)

(A)  $x^2 + x - 6 = 0$   
 $\Leftrightarrow (x+3)(x-2) = 0$   
 $\Leftrightarrow x = -3, x = 2$

(B)  $x^2 + 4x = 3$   
 $\Leftrightarrow (x+2)^2 - 2^2 = 3$   
 $\Leftrightarrow (x+2)^2 = 3+4 = 7$   
 $\Leftrightarrow x+2 = \pm\sqrt{7}$   
 $\Leftrightarrow x = 2 \pm \sqrt{7}$

sheet 1

gradex-overlay

Handwritten mathematical work on lined paper, identical to the left page. The student ID B090637 is visible at the top right. The work includes:

(1)

(A)  $x^2 + x - 6 = 0$   
 $\Leftrightarrow (x+3)(x-2) = 0$   
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 $\Leftrightarrow (x+2)^2 = 3+4 = 7$   
 $\Leftrightarrow x+2 = \pm\sqrt{7}$   
 $\Leftrightarrow x = 2 \pm \sqrt{7}$

sheet 1

Marker notes

Marker: GK

Bad scan

Page seen

Marks awarded

1a  /2

1b  /2

2  /4

Marker: GK

Bad scan

Page seen

Marks awarded

1a  /2

1b  /2

2  /4



# 3

# GradeX PDF

(a)  $x^2 + x - 6 = 0$

$\Leftrightarrow (x+3)(x-2) = 0$

$\Leftrightarrow x = -3, x = 2$

(b)  $x^2 + 4x = 3$

$\Leftrightarrow (x+2)^2 - 2^2 = 3$

$\Leftrightarrow (x+2)^2 = 3+4 = 7$

$\Leftrightarrow x+2 = \pm\sqrt{7}$

$\Leftrightarrow x = 2 \pm \sqrt{7}$

gkinnear 10:41 Reply X  
how did you find this factorisation?  
Add a reply...

Marks awarded  
1a 2 /2  
1b 2 /2  
2 /4

(2)  $y = x^3 - 2x^2 + 1$

$\Rightarrow \frac{dy}{dx} = 3x^2 - 4x$

When  $x=0$ ,  $\frac{dy}{dx} = 0$  and  $y = 1$ .

Therefore the equation of the tangent at  $x=0$  is

$y = 1$

graph?

Marks awarded  
1a /2  
1b /2  
2 3 /4



Exam:	MATH00000			
Marker:	GK			
	1a	1b	2	Total
out of:	2	2	4	8
mean:	1.2	1.33	3	4.75
mean (%):	60	66.7	75	59.375

Validation problems (3 scripts):

Exam Num	1a	1b	2	Total	Validation
B075837	1	0.5	4	5	1b: noninteger mark
B093651	1 + 1	1	2	5	1a: multiple marks
B094191	1	1		2	2: not marked

Marking completed (1 scripts):

Exam Num	1a	1b	2	Total	Validation
B090637	2	2	3	7	

Yet to be marked  
B097880  
B099142  
B101814

**Validation messages:**

- Non-integer marks
- Marks outside range
- Multiple marks
- Missing marks



# 3

# GradeX PDF

(a)  $x^2 + x - 6 = 0$   
 $\Leftrightarrow (x+3)(x-2) = 0$   
 $\Leftrightarrow x = -3, x = 2$

(b)  $x^2 + 4x = 3$   
 $\Leftrightarrow (x+2)^2 - 2^2 = 3$   
 $\Leftrightarrow (x+2)^2 = 3+4 = 7$   
 $\Leftrightarrow x+2 = \pm\sqrt{7}$   
 $\Leftrightarrow x = -2 \pm \sqrt{7}$

gkinnear 10:41 Reply X  
 how did you find this factorisation?  
 Add a reply...

Marks awarded  
 1a  /2  
 1b  /2  
 2  /4

(2)  $y = x^3 - 2x^2 + 1$  ✓  
 $\Rightarrow \frac{dy}{dx} = 3x^2 - 4x$   
 When  $x=0$ ,  $\frac{dy}{dx} = 0$  and  $y = 1$ .  
 Therefore the equation of the tangent at  $x=0$  is  
 $y = 1$  ✓ *graph?*

Marks awarded  
 1a  /2  
 1b  /2  
 2  /4



COURSE MATH00000 Summer 2020 STUDENT B090637  
 8090637

(a)  $x^2 + x - 6 = 0$   
 $\Leftrightarrow (x+3)(x-2) = 0$   
 $\Leftrightarrow x = -3, x = 2$

(b)  $x^2 + 4x = 3$   
 $\Leftrightarrow (x+2)^2 - 2^2 = 3$   
 $\Leftrightarrow (x+2)^2 = 3+4 = 7$   
 $\Leftrightarrow x+2 = \pm\sqrt{7}$   
 $\Leftrightarrow x = -2 \pm \sqrt{7}$

Marker notes  
 GK  
 Red scan  
 Page seen

Marks awarded Moderation  
 1a  /2  
 1b  /2  
 2  /4

sheet 1  
 how did you find this factorisation?

[0] how did you find this factorisation?

# 3

## GradeX PDF

- SharePoint to store files
- Marking on iPad: OneDrive app
- Test your PDF viewer!



# Moderation

- Checking process – less arithmetic!
- Paperless exam board:
  - Marking spreadsheets readily available
  - Borderline scripts easy to find



# Plans for 2020/21



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# A growing need...

- December exams – remote again
- In-course assessment (e.g. midterms)
- Low-stakes hand-in work



# Issues to address...

- Zoning – devolve to students
  - Gradescope?
  - Mix of STACK and human marking?

See “Human marking” at <https://eams.ncl.ac.uk/moodle/course/view.php?id=5>

- Streamlining the admin process
- Usability for markers



# Thank you!



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**Dr George Kinnear**

G.Kinnear@ed.ac.uk

 @georgekinnear

**Dr Steven O'Hagan**

s.ohagan@ed.ac.uk