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Development of Online Exams with Minimum Proctoring Requirement

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Development of online exams with minimum proctoring requirement

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Abstract

During the pandemic and after it, taking in-person exams has become tricky as there is always a higher possibility that there will be a student or two who will be absent due to possible infection or exposure to infected people. This has been especially problematic during the final exams (particularly during the fall semester due to higher infection rates in cold weather) as missing it means that the student will get an incomplete grade. Further the makeup exam will usually take place during the following semester at which time the students may have lost a critical touch with the course material and will be busy with the other courses. In any case, the course material is not as fresh as at the end of the semester. Therefore, it creates a hardship for the students. Based on my teaching experience of almost 20 years, a makeup final exam in the following semester mostly affects the grade negatively for the student.

This paper will present results on the development and execution of online exams in Blackboard environment, which can be administered with no proctoring. Details of how to develop such exams along with analysis of grades achieved by the students in two different undergraduate engineering courses will be presented. It is concluded that this is an effective way of taking exams while overcoming any hurdles due to possible illnesses of the students. This approach also has some additional benefits such as the students can take the exam at their best time and lengthier exams may be given for the courses requiring it.

Introduction

Starting from early 2000s, the introduction of online courses and the availability of online resources even for those students taking in-person classes has met with new challenges to implement in the course material including exams. These challenges have been addressed by several authors with different approaches and success. One of the key points is to understand that the students entering college campuses in this age have access to information in many forms that may blur the line between honest and dishonest behavior [1]. This may be simply due to the fact that students consider it cheating when someone looks at their neighboring student's solution in an exam room to copy it, but they may consider copying from an online source that provides the solution to a problem in the homework or exam to be acceptable. The covid-19 pandemic accelerated the move to online learning and online assessment especially for engineering courses that were slow in the transition due to the inherent nature of engineering programs and their requirements. However, there were several studies performed on the topic before the pandemic. Christe [2] outlined the key elements of an online multiple-choice questions, which are: writing questions that cannot be easily looked up in common reference materials, use time limits wisely and carefully select incorrect answers. The first two can be applied to questions that are not multiple-choice but require a calculated answer. Mehrabian et al. [3, 4] discussed how should faculty design online exams for students studying in engineering and technology related fields without sacrificing the educational quality and exam security and also provided faculty experiences on the topic. They presented following important recommendations to prepare online-open book-open mind approach exams: the students should be tested more on the concepts rather than the material that can be plagiarized easily and selecting random sets of questions from a pool of questions for each student. For the second part, more questions should be setup in the learning management system so that the system can randomized the exam for each student. Pohl and Pohl [5] argued that the advantage of online exams is that these can be taken in any location, however if the exam is open for several days, then there is a possibility that the students may communicate about the content of the exam. Karimi et al. [6] outlined challenges in both instruction and assessment during the pandemic. They cite difficulty in assessing the student learning due to availability of solution manuals online, communication between students using their phone, and third-party tutoring services. They suggest proctoring through video is the best and cite certain issues conducting non-proctored exams, even if these are randomized. Gayle and Mangara [7] have argued against the video proctoring citing legal and privacy issues. They present three strategies to use inside the learning management system, which are: develop the right question, limit the time and testing window, use a pool of questions. These recommendations are similar to the ones proposed by Mehrabian et al. [3, 4]. Another aspect is the popping up of several study help websites, e.g. chegg.com, study.com, brainly.com to name a few. Broemer and Recktenwald [8] presented an analysis on the abuse of chegg.com during online exams with statistics including on efficacy of cheating in using such websites. According to their data, about two-third of students posted questions to chegg.com, but only one-third actually looked at the solution provided by chegg.com before the end of the exam. This is attributed to the guilt that those students felt and did not actually looked at the solution provided by chegg.com, which points to the solution that properly instilled academic integrity awareness is the key to curb cheating in any form. Gehringer [9] has outlined advantages and disadvantages of online exams and argues that while online exams remove some modes of cheating because all materials are authorized, it introduces other possibilities of cheating some of which have already been discussed. Gehringer et al. [10] summarized the tools available to faculty in detecting plagiarism in the online exams. Davis et al. [11] outlined, with specific detailed examples, how to generate exams in the Blackboard learning environment.

In this paper, several examples of exam question developed in Blackboard for different courses in an engineering program will be presented and discussion will be provided on their relative merit and usefulness for each course.

Development of Questions in Blackboard

Since the exam questions are developed in Blackboard environment, types of questions available in Blackboard and the ones used in this study will be introduced first. Blackboard can generate following types of questions (in the same order as these appear in Blackboard):

- Calculated Formula
- Calculated Numeric
- Either/Or
- Essay
- File Response
- Fill in Multiple Blanks
- Fill in the Blank

- Hot Spot
- Jumbled Sentence
- Matching
- Multiple Answer
- Multiple Choice
- Opinion Scale/Likert
- Ordering
- Quiz Bowl
- Short Answer
- True/False

For this study, two types of questions will be used: Calculated Formula and File Response. *Calculated Formula* question allows to use a range of numerical values for declared variables (which should be declared by enclosing these in square brackets) and generates a set of possible solution such that each student will get a problem with different numerical values. To generate a question of this type, the instructor needs to provide a statement with embedded variables' declaration and then provide a formula to calculate the answer using the declared variables. The formula can be a simple one or as complicated as needed, and it may or may not use all declared variables (i.e. superfluous data is allowed) along with constant values. It also allows to generate as many data sets with different numerical values as desired based on the number of students. The *Calculated Formula* questions are automatically graded by Blackboard based on a given range (numeric or percentage) with a manual override by the instructor, if needed. *File Response* question allows the student to upload a file with the solution, in response to a prompt, to be graded by the instructor later.

Here, we will use these two question types in combination to develop exam problems that can be assigned as a take home exam. First, development of several questions will be presented using this approach and then the mechanics of delivering these questions will be presented.

An Example Question from Dynamics of Machines

Figure 1a represents a problem from dynamics of machines course in a form suitable for in-person exams. The problem shows a four-bar mechanism with given dimensions, and the angular velocity of the crank. The solution includes drawing a scaled position diagram and a scaled velocity polygon.

For the four-bar linkage, assume that $\omega_2 = 4$ rad/s cw. Write the appropriate vector equations and solve them using vector polygons determining, when $\theta_4 = 53^o$:

(a) θ_2,
(b) v_C, ω_3, ω_4.

$AB = 150$ mm, $BC = 135$ mm, $CD = 165$ mm.
Do not forget to indicate the senses of rotation for ω_3 and ω_4.

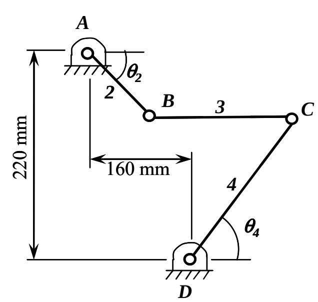
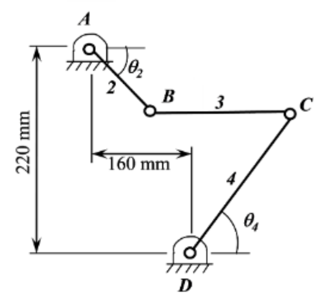


Fig 1a: Problem as given for an in-person exam – Dynamics of Machines

Figures 1b shows the problem as developed in the Blackboard. The first part is a *Calculated Formula* question that declares the angular velocity of link 2 and the length of *CD* and its angle as variables. Then it asks a simple question that can be answered by the student after drawing the scaled position diagram. However, for Blackboard, we must use a geometric formula using trigonometry, which is simply the horizontal distance from *A* to *D* plus *CD* times the cosine of angle θ_4. Then the *File Response* question in the second part asks for a detailed solution with answers for specific velocities. Since the numerical values will be different, the students must draw both the position diagram and the velocity polygon from scratch, and it cannot be shared with others. The purpose of the simple *Calculated Formula* question in the first part is to introduce the variables so that students will get questions with different numerical values for the declared variables and to check if the student has drawn the position diagram correctly. The *File Response* question does not have the capability to introduce variables in the question.

1. Calculated Formula: 2a: For the four-bar linkage, AB = 150 mm... Points: 1

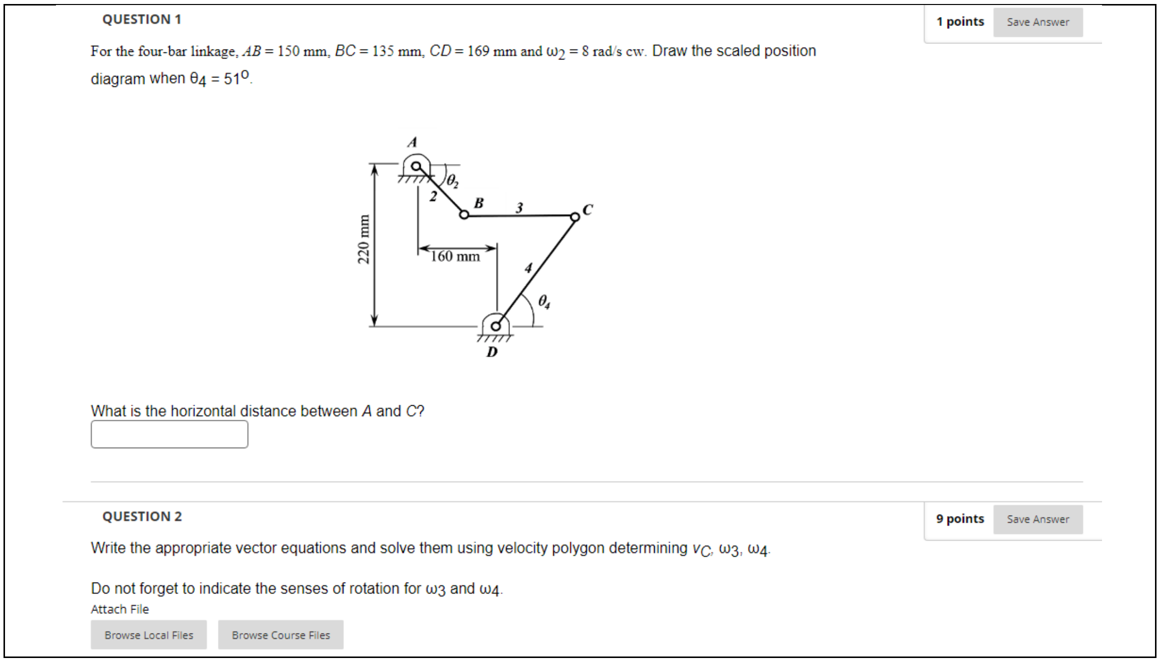
Question	For the four-bar linkage, AB = 150 mm, BC = 135 mm, CD = [l] mm and ω_2 = [omega] rad/s cw. Draw the scaled position diagram when θ_4 = [theta]°.  What is the horizontal distance between *A* and *C*?
Answer Formula	160 + 1 * cos(theta/57.3)
Precision	Decimal
Answer Range +/-	± 2
Number of Answer Sets	10

2. File Response: 2b: Write the appropriate vector equation... Points: 9

Question	Write the appropriate vector equations and solve them using velocity polygon determining v_C, ω_3, ω_4. Do not forget to indicate the senses of rotation for ω_3 and ω_4.

Fig 1b: Problem as developed for an online exam (instructor view) – Dynamics of Machines

Figure 1c shows the developed question, with random values for the declared values, in the form that will be given to students to attempt.



QUESTION 1

1 points Save Answer

For the four-bar linkage, AB = 150 mm, BC = 135 mm, CD = 169 mm and ω_2 = 8 rad/s cw. Draw the scaled position diagram when $\theta_4 = 51^o$.

What is the horizontal distance between A and C?

QUESTION 2

9 points Save Answer

Write the appropriate vector equations and solve them using velocity polygon determining v_C, ω_3, ω_4.

Do not forget to indicate the senses of rotation for ω_3 and ω_4.

Attach File

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Fig 1c: Problem as given for an online exam (student view) – Dynamics of Machines

An Example Question from Machine Design

Figure 2a represents a problem from machine design course in a form suitable for in-person exams. The problem is from stress concentration topic. The solution involves determination of a stress concentration factor using an appropriate plot for the given geometry, and then finding the maximum stress based on the stress concentration factor and the nominal stress. Usually, various stress concentration factor plots are provided to the students to pick the correct one for the given geometry.

Determine the maximum stress at the notch?

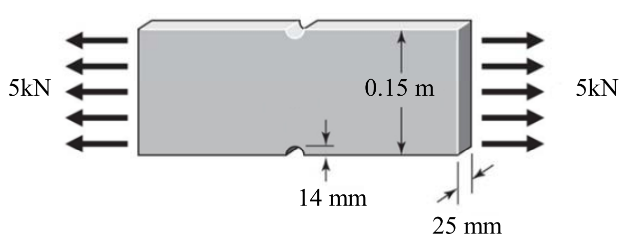
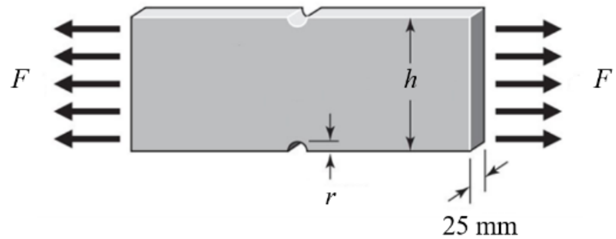


Fig 2a: Problem as given for an in-person exam – Machine Design

Figures 2b shows the problem as developed in the Blackboard. The first part is a *Calculated Formula* question that declares the width of the plate, notch radius and the force applied as variables. The given formula includes conversions from m to mm and from kN to N, so that the final answer is in MPa, the units in which the problem is asking the answer to be in. Then the *File Response* question in the second part asks for a detailed solution with answers for stress concentration factor and the maximum stress. A soft copy of plots of possible stress concentration factors is uploaded to Blackboard before the start of the exam and the students are required to submit the one that they have used with their solution.

1. **Calculated Formula: 3a: For the notched specimen with h = [h]...** Points: 1

Question	For the notched specimen with *h* = [h] m and *r* =[r] mm, calculate the nominal stress for *F* =[F] kN. Answer must be given in MPa.



Answer Formula	1000 * F / (25 * ((h * 1000) − (2 * r)))
Precision	Decimal
Answer Range +/-	± 0.1
Number of Answer Sets	20

2. **File Response: 3b: For the problem in 3a, determine: the...** Points: 4

Question

For the problem in 3a, determine:

a. the stress concentration factor at the notch,
b. the maximum stress at the notch?

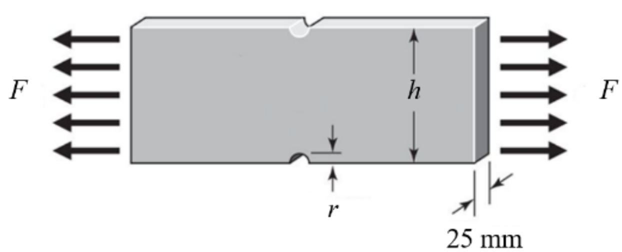
Solve on paper, scan, submit.

Fig 2b: Problem as developed for an online exam (instructor view) – Machine Design

Figure 2c shows the developed question, with random values for the declared values, in the form that will be given to students to attempt.

QUESTION 1 **1 points** Save Answer

For the notched specimen with *h* = 0.18 m and *r* =14 mm, calculate the nominal stress for *F* =4 kN.
Answer must be given in MPa.



QUESTION 2 **4 points** Save Answer

For the problem in 3a, determine:

a. the stress concentration factor at the notch,
b. the maximum stress at the notch?

Solve on paper, scan, submit.
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Fig 2c: Problem as given for an online exam (student view) – Machine Design

An Example Question from Vibrations

Figure 3a represents a problem from vibrations course in a form suitable for in-person exams. The problem shows the governing equation for two degrees of freedom system in matrix form (mass and stiffness matrices given) and asks to calculate the spectral and modal matrices.

Calculate the spectral matrix $[\Lambda]$ and the modal matrix $[P]$ for the following problem:

$$\begin{bmatrix} 625 & 0 \\ 0 & 100 \end{bmatrix}\{\ddot{x}\} + \begin{bmatrix} 1000 & -1000 \\ -1000 & 11000 \end{bmatrix}\{x\} = \{0\}$$

Fig 3a: Problem as given for an in-person exam – Vibrations

Figures 3b shows the problem as developed in the Blackboard. The first part is a *Calculated Formula* question that declares the mass m_1 and stiffness k_1 as variables and asks to give the value of the larger eigenvalue as the answer. The calculation of eigenvalues is a necessary step during the calculation of the spectral and modal matrices, and it involves matrix operations. The formula shown in Fig. 3b is obtained using Mathcad by symbolically solving the characteristic equation of the governing differential equation. The students must solve the equation with values given to them. Then the *File Response* question in the second part asks for a detailed solution including both spectral and modal matrices.

1. **Calculated Formula: 5a: Consider the system. m1 = [m] kg,...** Points: 1

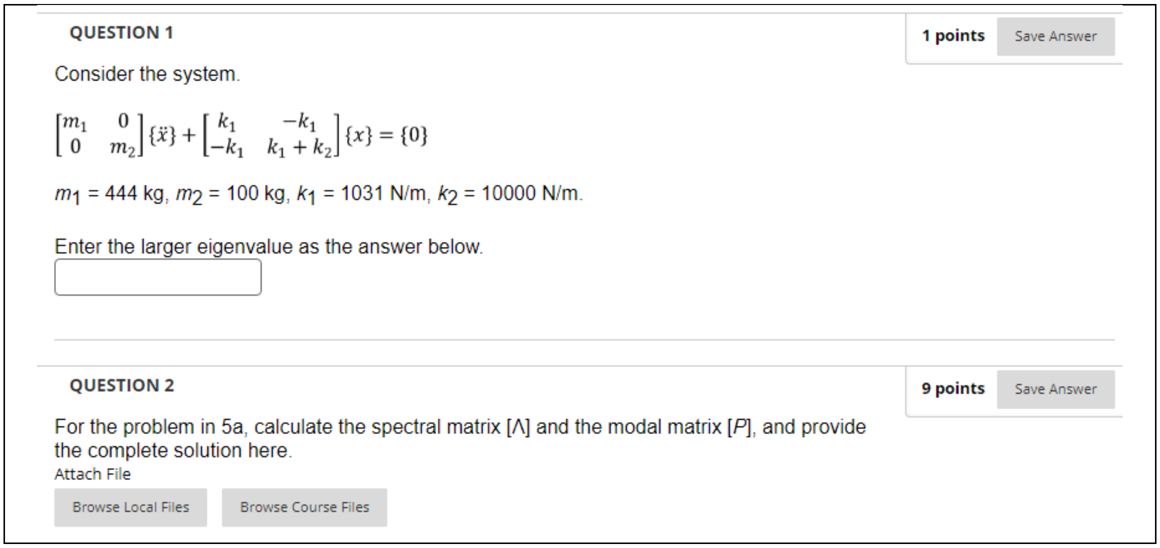
Question	Consider the system. $\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix}\{\ddot{x}\} + \begin{bmatrix} k_1 & -k_1 \\ -k_1 & k_1 + k_2 \end{bmatrix}\{x\} = \{0\}$ m_1 = [m] kg, m_2 = 100 kg, k_1 = [k] N/m, k_2 = 10000 N/m. Enter the larger eigenvalue as the answer below.
Answer Formula	$(\sqrt{((0.00025*k^2+0.5*k+2500)*m^2+(0.005*k^2-50*k)*m+0.25*k^2)} + (0.005*k+50)*m+0.5*k)/m$
Precision	Decimal
Answer Range +/-	± 2
Number of Answer Sets	20

2. **File Response: 5b: For the problem in 5a, calculate the ...** Points: 9

Question	For the problem in 5a, calculate the spectral matrix [Λ] and the modal matrix [*P*], and provide the complete solution here.

Fig 3b: Problem as developed for an online exam (instructor view) – Vibrations

Figure 3c shows the developed question, with random values for the declared values, in the form that will be given to students to attempt.



QUESTION 1 — 1 points — Save Answer

Consider the system.

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix}\{\ddot{x}\} + \begin{bmatrix} k_1 & -k_1 \\ -k_1 & k_1 + k_2 \end{bmatrix}\{x\} = \{0\}$$

m_1 = 444 kg, m_2 = 100 kg, k_1 = 1031 N/m, k_2 = 10000 N/m.

Enter the larger eigenvalue as the answer below.

QUESTION 2 — 9 points — Save Answer

For the problem in 5a, calculate the spectral matrix [Λ] and the modal matrix [*P*], and provide the complete solution here.

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Fig 3c: Problem as given for an online exam (student view) – Vibrations

An Example Question from Software Tools for Engineers (STfE)

Software tools for engineers is a first-year course that is designed to introduce students to software tools including Excel, Visual Basic Applications (VBA) and Matlab. Figure 4a represents a problem from the VBA portion of the course in a form suitable for in-person exams. The problem involves calculating the downward velocity of a parachutist before and after the deployment of the parachute after the jump. The students are given a sample Excel sheet but they are free to design their own. The bulk of the solution involves programming in VBA.

Figures 4b shows the problem as developed in the Blackboard. The first part is a *Calculated Formula* question that declares the mass of the parachutist, the drag coefficient before the deployment of the parachute and the time elapsed when the parachutist deploys the parachute as variables. It then asks for the velocity of the parachutist at the instant the parachute is deployed. Then the *File Response* question in the second part asks for the Excel file with detailed solution. For such courses, in addition to generating problems with different numerical values, this method allows for longer problems to be assigned that may be difficult to assign as exam problems in an in-person exam due to time constraints. It is very obvious if two students submit the same VBA code and to see the history of the Excel file to discourage cheating among students.

When a parachutist jumps from a plane, the downward velocity $v(t)$ can be computed as:

$$v(t) = v_0 e^{-\left(\frac{c_d}{m}\right)t} + \frac{gm}{c_d}\left(1 - e^{-\left(\frac{c_d}{m}\right)t}\right) \quad \text{for } t \le t_c \qquad (1)$$

Where:

v_0 = Initial downward velocity (m/s)
m = mass of the parachutist (kg)
c_d = drag coefficient accounting for air resistance (kg/s)
t = time (s)
g = acceleration due to gravity (= 9.81 m/s^2)

After the parachute is deployed:

t_c = the elapsed time when the parachutist pulls the cord to deploy the parachute
v_{0_p} = Initial downward velocity at the instant parachute is deployed (m/s)
c_{dp} = drag coefficient accounting for air resistance after the parachute is deployed (kg/s)

The equations for v_{0p} and $v_p(t)$ after the parachute is deployed are given as:

$$v_{0p} = v_0 e^{-\left(\frac{c_d}{m}\right)t_c} + \frac{mg}{c_d}\left(1 - e^{-\left(\frac{c_d}{m}\right)t_c}\right)$$

$$v_p(t) = v_{0p} e^{-\left(\frac{c_{dp}}{m}\right)(t-t_c)} + \frac{mg}{c_{dp}}\left(1 - e^{-\left(\frac{c_{dp}}{m}\right)(t-t_c)}\right) \quad \text{for } t > t_c \qquad (2)$$

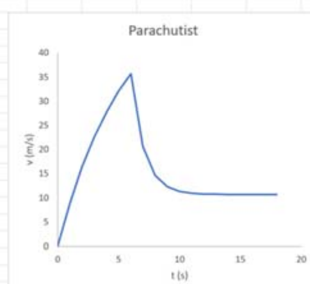
Setup an Excel sheet as shown below (you are free to use your own format), then write a VBA macro to:

i) Receive v_0, m, c_d, c_{dp}, and t_c as input from the user and populate the sheet with these values. The InputBox must mention the name of variable to be entered with the acceptable units.
ii) Receive the total time t and time interval, Δt (the distance between two consecutive calculations, the Step in your loop) at which the parachutist's velocity is required to be calculated.
iii) Calculate parachutist's velocity for time ranging from 0 to t using an interval of Δt (you may want to develop a Function to calculate the velocity).
iv) Place these values (t, v) on the excel sheet after each calculation (Note: The total number of values will depend on t and Δt entered by the user. Make sure nothing is left behind from previous runs/results in these columns).

Parachutist

Initial velocity v_o =	0 m/s
Mass of the parachutist m =	68 kg
Drag coefficient c_d =	12.5 kg/s
Parachute deploy time t_c =	6 s
Drag coefficient with parachute c_{dp} =	62.5 kg/s

t (s)	v (m/s)
0	0
1	8.96115
2	16.4176
3	22.6219
4	27.7844
5	32.0801
6	35.6544
7	20.6375
8	14.6477
9	12.2586
10	11.3056
11	10.9255
12	10.7739
13	10.7134
14	10.6893
15	10.6797
16	10.6758
17	10.6743
18	10.6737



Manually plot $v(t)$ vs t.

Fig 4a: Problem as given for an in-person exam – STfE

1. **Calculated Formula: 3a: When a parachutist jumps from a plane...** Points: 1

Question

When a parachutist jumps from a plane, the downward velocity v(t) can be computed as:

$$v(t) = v_0 e^{-\left(\frac{c_d}{m}\right)t} + \frac{gm}{c_d}\left(1 - e^{-\left(\frac{c_d}{m}\right)t}\right) \qquad \text{for } t \le t_c \qquad (1)$$

Where:

v_0 = Initial downward velocity (m/s)
m = mass of the parachutist (kg)
c_d = drag coefficient accounting for air resistance (kg/s)
t = time (s)
g = acceleration due to gravity (= 9.81 m/s^2)

After the parachute is deployed:

t_c = the elapsed time when the parachutist pulls the cord to deploy the parachute
v_{0p} = Initial downward velocity at the instant parachute is deployed (m/s)
c_{dp} = drag coefficient accounting for air resistance after the parachute is deployed (kg/s)

The equations for v_{0p} and $v_p(t)$ after the parachute is deployed are given as:

$$v_{0p} = v_0 e^{-\left(\frac{c_d}{m}\right)t_c} + \frac{mg}{c_d}\left(1 - e^{-\left(\frac{c_d}{m}\right)t_c}\right)$$

$$v_p(t) = v_{0p} e^{-\left(\frac{c_{dp}}{m}\right)(t-t_c)} + \frac{mg}{c_{dp}}\left(1 - e^{-\left(\frac{c_{dp}}{m}\right)(t-t_c)}\right) \qquad \text{for } t > t_c \qquad (2)$$

Setup an Excel sheet as shown below (you are free to use your own format), then write a VBA macro to:

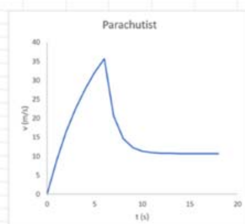
i. Using InputBox, receive v_0, m, c_d, c_{dp}, and t_c as input from the user and populate the sheet with these values. The InputBox must mention the name of variable to be entered with the acceptable units.
ii. Using InputBox, receive the total time t and time interval, Δt (the distance between two consecutive calculations, the Step in your loop) at which the parachutist's velocity is required to be calculated.
iii. Calculate parachutist's velocity for time ranging from 0 to t using an interval of Δt (you may want to develop a Function to calculate the velocity).
iv. Place these values (t, v) on the excel sheet after each calculation (Note: The total number of values will depend on t and Δt entered by the user. Make sure nothing is left behind from previous runs/results in these columns).

Manually plot $v(t)$ vs t.

Parachutist

Initial velocity v_o =	0 m/s
Mass of the parachutist m =	68 kg
Drag coefficient c_d =	12.5 kg/s
Parachute deploy time t_c =	6 s
Drag coefficient with parachute c_{dp} =	62.5 kg/s

t (s)	v (m/s)
0	0
1	8.96115
2	16.4176
3	22.6219
4	27.7844
5	32.0801
6	35.6544
7	20.6375
8	14.6477
9	12.2586
10	11.3056
11	10.9255
12	10.7739
13	10.7134
14	10.6893
15	10.6797
16	10.6758
17	10.6743
18	10.6737



What will be the value of v_{0p} (in m/s) for the following values:
v_0 = 0, m = [m] kg, c_d = [cd] kg/s, c_{dp} = 62.5 kg/s, t_c =[tc] s, t = 18 s, Δt = 0.5 or 1 s.

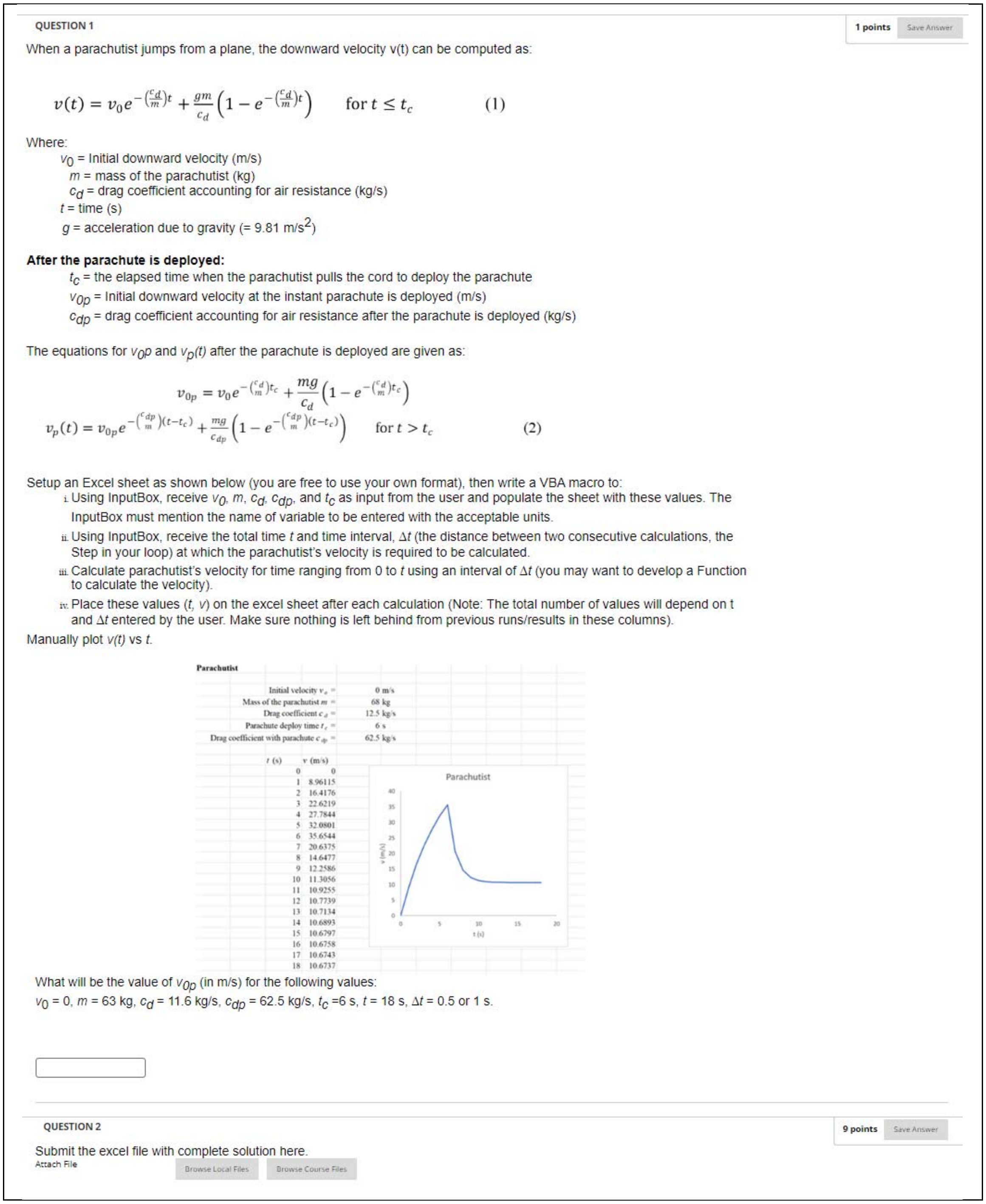
Answer Formula	(9.81 * m/cd) * (1 - exp(-1 * cd * tc/m))
Precision	Decimal
Answer Range +/-	± 1
Number of Answer Sets	10

2. **File Response: 3b: Submit the excel file with complete s...** Points: 9

Question Submit the excel file with complete solution here.

Fig 4b: Problem as developed for an online exam (instructor view) – STfE

Figure 4c shows the developed question, with random values for the declared values, in the form that will be given to students to attempt.



QUESTION 1 — 1 points — Save Answer

When a parachutist jumps from a plane, the downward velocity v(t) can be computed as:

$$v(t) = v_0 e^{-\left(\frac{c_d}{m}\right)t} + \frac{gm}{c_d}\left(1 - e^{-\left(\frac{c_d}{m}\right)t}\right) \qquad \text{for } t \le t_c \qquad (1)$$

Where:
v_0 = Initial downward velocity (m/s)
m = mass of the parachutist (kg)
c_d = drag coefficient accounting for air resistance (kg/s)
t = time (s)
g = acceleration due to gravity (= 9.81 m/s^2)

After the parachute is deployed:
t_c = the elapsed time when the parachutist pulls the cord to deploy the parachute
v_{0p} = Initial downward velocity at the instant parachute is deployed (m/s)
c_{dp} = drag coefficient accounting for air resistance after the parachute is deployed (kg/s)

The equations for v_0p and $v_p(t)$ after the parachute is deployed are given as:

$$v_{0p} = v_0 e^{-\left(\frac{c_d}{m}\right)t_c} + \frac{mg}{c_d}\left(1 - e^{-\left(\frac{c_d}{m}\right)t_c}\right)$$

$$v_p(t) = v_{0p} e^{-\left(\frac{c_{dp}}{m}\right)(t-t_c)} + \frac{mg}{c_{dp}}\left(1 - e^{-\left(\frac{c_{dp}}{m}\right)(t-t_c)}\right) \qquad \text{for } t > t_c \qquad (2)$$

Setup an Excel sheet as shown below (you are free to use your own format), then write a VBA macro to:

i. Using InputBox, receive v_0, m, c_d, c_{dp}, and t_c as input from the user and populate the sheet with these values. The InputBox must mention the name of variable to be entered with the acceptable units.
ii. Using InputBox, receive the total time t and time interval, Δt (the distance between two consecutive calculations, the Step in your loop) at which the parachutist's velocity is required to be calculated.
iii. Calculate parachutist's velocity for time ranging from 0 to t using an interval of Δt (you may want to develop a Function to calculate the velocity).
iv. Place these values (t, v) on the excel sheet after each calculation (Note: The total number of values will depend on t and Δt entered by the user. Make sure nothing is left behind from previous runs/results in these columns).

Manually plot $v(t)$ vs t.

Parachutist

Initial velocity v_o =	0 m/s
Mass of the parachutist m =	68 kg
Drag coefficient c_d =	12.5 kg/s
Parachute deploy time t_c =	6 s
Drag coefficient with parachute c_{dp} =	62.5 kg/s

t (s)	v (m/s)
0	0
1	8.96115
2	16.4176
3	22.6219
4	27.7844
5	32.0801
6	35.6544
7	20.6375
8	14.6477
9	12.2586
10	11.3056
11	10.9255
12	10.7739
13	10.7134
14	10.6893
15	10.6797
16	10.6758
17	10.6743
18	10.6737

What will be the value of v_{0p} (in m/s) for the following values:
v_0 = 0, m = 63 kg, c_d = 11.6 kg/s, c_{dp} = 62.5 kg/s, t_c =6 s, t = 18 s, Δt = 0.5 or 1 s.

QUESTION 2 — 9 points — Save Answer

Submit the excel file with complete solution here.
Attach File — Browse Local Files — Browse Course Files

Fig 4c: Problem as given for an online exam (student view) – STfE

Mechanics of Delivering the Tests

Once the Questions are developed, these can be added to Tests in Blackboard (the reverse order can be followed too, i.e. start from Test and then add Questions to it). Tests in Blackboard offer several options including the time allowed, availability of the test, if the test be forced closed at the end of given time, if the students are allowed to start an exam after the due date/time. It is important to control all of these options correctly to discourage and prevent cheating. The students are allowed to start the test at any time of their choice during the test availability hours. Once they start, they must finish in the given time (theoretically infinite time can be given). The amount of time given for a particular test should be precisely controlled [2,7] so that the student does not have time to consult any other resources. Once they start the test and get a question with a particular set of numerical values, they should have just enough time to solve it. The students must be reminded that they should study the material before hand and completely understand it. There will be no time to go over the material during the test. The expectations of the test and academic integrity should be clearly outlined in the instructions before starting the test [1,2].

Lessons Learned

The quizzes usually have one problem, but the midterm/final exams have more than one problem. Both are called Tests in Blackboard and Tests can be developed with more than one problem. However, grading those Tests becomes difficult. With paper exams, the same problem is graded for all students as this is quicker, focused and provides uniform grading for all students. If there are more than one Question in a Test, then it becomes inherently difficult and time consuming to grade the same problem for all students, and then move on to the next problem. This is due to the fact that Blackboard lets to go from one student to the next student after grading all problems for one student, but not from one student to the next for the same problem. To overcome this issue, midterm/final exams should be developed as one Question per Test, and the exam is delivered in several Tests. Then it is possible to grade the same problem for all students, and then move on to the next Test/problem. This approach has an added advantage for students. They do not need to complete the whole exam in one sitting. They can take a break between attempting the different parts of the exam, which usually has a positive effect on their grades. I frequently see many students attempt the different parts/Tests of the exam at different times.

This approach can be used with different courses with a different focus. The *Calculated Formula* part can be used with simple questions just to introduce different numerical values (e.g., the aforementioned question for dynamics of machines course) or to ask for a more involved question (e.g., the aforementioned question for vibrations course). In case of the VBA (or generally a programming) problem, it can be used to ask questions that take longer time and having an in-person exam may not be feasible. Although the examples presented here are specific to Blackboard environment, the mechanism could be applied to other course/learning management programs.

Figure 5 represents comparison between in-person and online quiz. These quizzes were taken during the spring semester 2023. Out of twenty students, five performed better on the online exam while four performed better on the in-person quiz and the remaining students performed the same. There could be several reasons for these observations. Those students, who performed better in the in-person exams are possibly used to having quizzes/exams in a classroom setting or maybe they were simply better prepared for the material covered in Quiz 2. The students who performed better on the online exam may have attempted the exam at a time when they are at their best. The use of online exams with open book, open mind, location of choice options has certain advantages for certain students [3, 5]. Being at a smaller teaching campus in a rural area and smaller class size, I teach 4-5 courses to the same students and have a certain degree of understanding of their learning capabilities, which helps me to notice if a student is performing too well on the online exams. This advantage may not be available to an instructor at larger campuses or classes in a large-class format.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Quiz 1 Online	5.5	7	7	10	10	10	9.5	8.5	7	10	7.5	10	10	6.5	10	6.5	9	8.5	6.5	4.5
Quiz 2 In-person	7	6	5	6	8	10	5	9	7	3	7	10	8	8	9	5	9	7	7	2

Fig 5: Comparison of in-person and online quiz – Vibrations

Future Directions

The data presented in Fig. 5 is preliminary and only from one course. I intend to have a better mix of both in-person and online tests for more than one course to collect better statistical data during this semester. In addition, I will be developing a set of questions for the same quiz so that the questions (and not only numerical values) can be randomized between students [6, 7]. For this purpose, the questions must be of similar difficulty and approach so that it is just for all students. The randomization of the questions will introduce more work in grading as all students will not get the same problem.

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