Automatic grading and feedback

OpenTA

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INSTITUTIONEN FÖR FYSIK

OpenTA

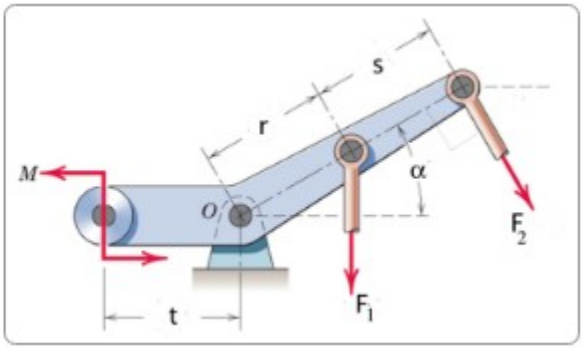
Goals:

- E-learning system for questions with symbolic answer.
- Effective user interface for students and teachers on computer, tablet and mobile.
- Easy feedback teacher  student

In a physics class, exercises typically involve some practical problem to be solved. Often analytically. A typical question from the earliest part of the mechanics course as presented in OpenTA is given in the following lide.

Exercise example

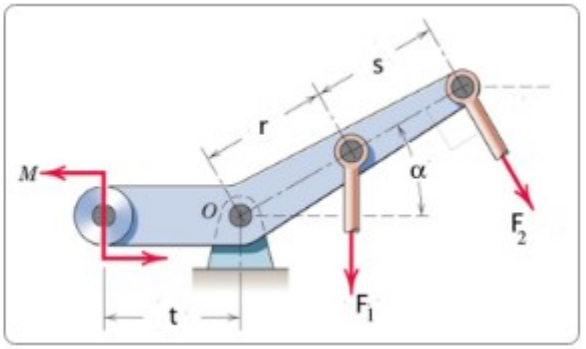
Systemet givet av kraftparet M samt krafterna F_1 och F_2 kan ersättas med en resulterande kraft med en given verkningslinje. (**Antag att** $F_1 > 0, F_2 > 0$). Beräkna vridmomentet M samt storleken på resultanten av systemet givet att verkningslinjen för resultanten passerar genom O.



The difficulty in evaluating a students answer to this is that
There are many equivalent responses that are correct and
acceptable. An autocorrecting system must accept all correct answers.

Exercise example

Systemet givet av kraftparet M samt krafterna F_1 och F_2 kan ersättas med en resulterande kraft med en given verkningslinje. (**Antag att** $F_1 > 0, F_2 > 0$). Beräkna vridmomentet M samt storleken på resultanten av systemet givet att verkningslinjen för resultanten passerar genom O.



Form of a correct answer may vary

$$\sqrt{(F1 + F2 \cdot \cos(\alpha))^2 + (F2 \cdot \sin(\alpha))^2}$$

$$\sqrt{F1^2 + F2^2 + 2 \cdot F1 \cdot F2 \cdot \cos(\alpha)}$$

$$\sqrt{(|F2| \ \sin(\alpha))^2 + (|F1| + |F2| \ \cos(\alpha))^2}$$

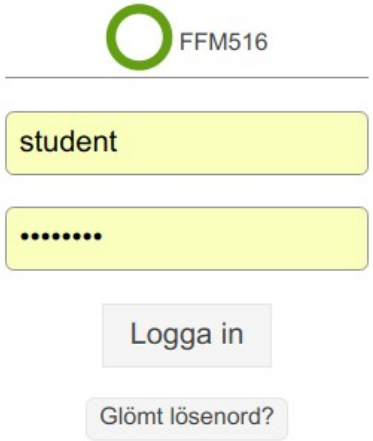
$$\sqrt{(F1)^2 + 2\,F1\,F2\,\cos(\alpha) + (F2)^2}$$

This is the challenge which is surprisingly difficult to meet.
The goal is therefore an exercise teaching platform that can
properly evaluate mathematical content in questions, not only
the usual numerical and multiple choice answers that are used
as quizzes in many teaching platform.

The goal is to make the exercises fun and instructive for the students,
and allow them to use the ``tools'' that they use every day. I ie
The platform should be adaptible usable not only on
laptops but should be usable on tablets and mobile phones.

User interface is important for adoption

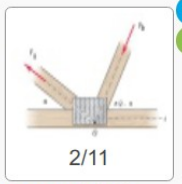
We first take a look at how a student sees the platform in our Mek1 course. First a login screen. In fact a launch in Canvas can also be used.

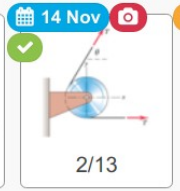

FFM516
student
Logga in
Glömt lösenord?

After OpenTA is started, folders with assignments are presented. In this case some icons that indicate which problems are to be solved. Some icons have embellishments that we will come back to.

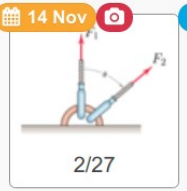
The following example comes from the Chalmers course in introductory mechanics.

- Dynamik
- Statik
  - Intro v1
  - Statik v2


2/11



2/13



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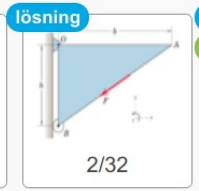
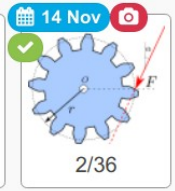
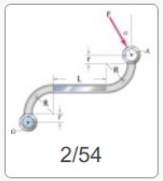
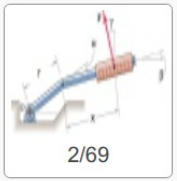


2/32



2/36

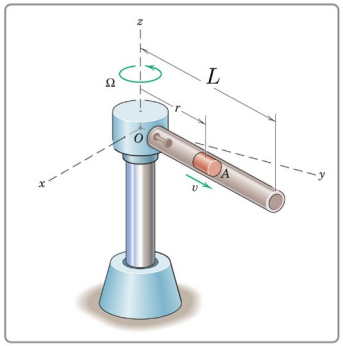

2/54


2/69

2/87

The student selects a problem and is presented with on or several questions to be answered and an answerbox in which to type the answer.

3/86



Det ihåliga röret med längden L roterar runt en vertikal axel genom O med en konstant vinkelhastiget $\dot{\theta} = \omega$. En cylinder med massa m glider friktionsfritt inuti röret. Cylindern börjar på ett avstånd r_0 och har då farten v_0 längs röret. Beräkna magnituden av den horisontella kraften P som verkar på cylindern precis när den lämnar röret. Svara i termer av L, v0, m, omega och r0.

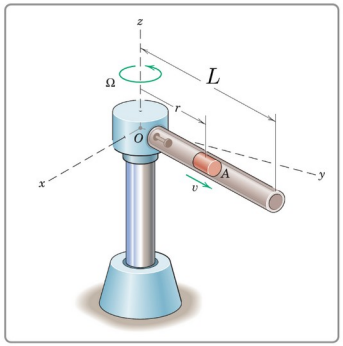
$|P|$

(i termer av v0, r0, L, m, omega)

A A A

The variables that are permited in the answer is indicated and the answer is entered in a natural asciimath syntax. The program typesets the input durint input, which is not only useful for checking more complex formulas, but is also fun since the input looks quite a bit more elegant than the asciimath input form.

3/86



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$|P|$

(i termer av v0, r0, L, m, omega)

2 m omega sqrt(v0 + omega^2 (L^2 - r0^2))

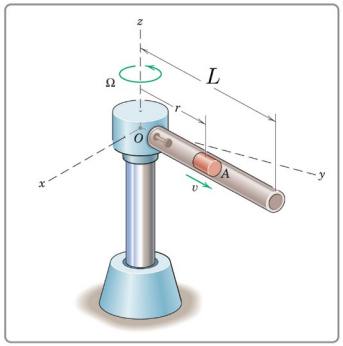
$$2 \cdot m \cdot \omega \cdot \sqrt{v_0 + \omega^2 \cdot (L^2 - {r_0}^2)}$$

A A A

The student attempts the answer by pressing ”Send”

In this case the answer was not only incorrect but the units were wrong, something that OpenTA points out in the response.

3/86



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$|P|$

(i termer av v0, r0, L, m, omega)

2 m omega sqrt(v0 + omega^2 (L^2 - r0^2))

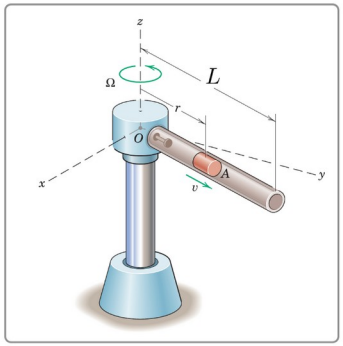
Uttrycket verkar inte ha rätt enhet.

$2 \cdot m \cdot \omega \cdot \sqrt{v_0 + \omega^2 \cdot (L^2 - {r_0}^2)}$ är inte korrekt.

A A A

On the next attempt, the student puts in the correct answer and gets a correct response back.

3/86



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$|P|$

(i termer av v0, r0, L, m, omega)

2 m omega sqrt(v0^2 + omega^2 (L^2 - r0^2))

$2 \cdot m \cdot \omega \cdot \sqrt{v_0^2 + \omega^2 \cdot (L^2 - r_0^2)}$ är korrekt.

A A A

The examiner can demand not only that the input answer is correct, but can indicate that the student should upload their calculations that led to the answer. In that case a camera icon is shown and eithere an image or pdf is uploaded by the students to complete the exercise.

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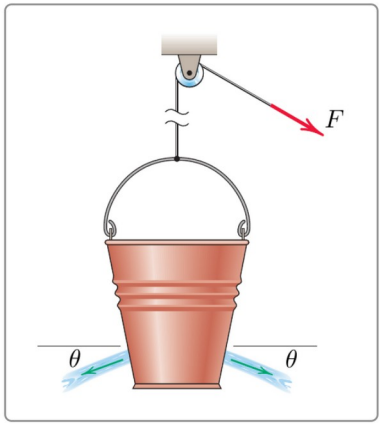


Hinken i figuren släpps från vila med initiala massan M (hink och vatten). Vattnet flödar ut genom hålen med farten v, totala massflödet m' (båda hålen tillsammans) och vinkeln θ enligt figuren. Samtidigt drar en kraft F i snöret. Beräkna hinkens acceleration med positiv riktning uppåt i figuren.

a

(i termer av g, F, M, mdot ($\dot{m}$), v, theta)

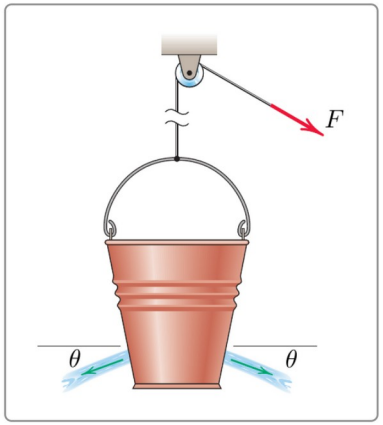
F/M - g + mdot/M v sin(theta)

$\frac{F}{M} - g + \frac{\dot{m}}{M} \cdot v \cdot \sin(\theta)$ är korrekt.

A A A

A thumbnail of the upload is then shown.

4/76



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$\frac{F}{M} - g + \frac{\dot{m}}{M} \cdot v \cdot \sin(\theta)$ är korrekt.

A A A

The previous slides shows OpenTA on a laptop screen, but the mobile format is sufficiently easy to use that many of the students use that instead of a laptop. An, the uploads can be done directly from the camera of the mobile.

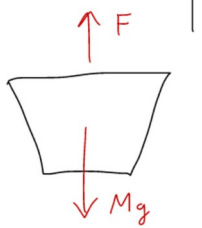
4/76

2019-11-12 16:09:18.132165

Sökt: Hinkens accelerationen.

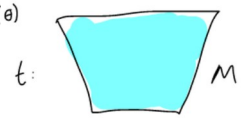
Givet: Initiala massan M, kraften F, vinkeln , flödeshastigheten v, massflödet m'.

Plan: Analysera flödet vid t och $t+\Delta t$ med $\Delta G = \sum_i F_i \Delta t$.



$$G_t = 0$$

$$G_{t+\Delta t} = (M - \Delta m)\Delta V - \Delta m v \sin(\theta)$$

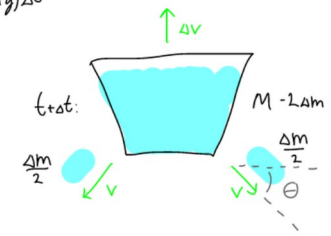


$$\Delta G = \sum_i F_i \Delta t$$

$$\Rightarrow \quad M\Delta V - \Delta m v \sin(\theta) = (F - Mg)\Delta t$$

$$\Rightarrow \quad a = \frac{F}{M} - g + \frac{m'}{M} v \sin(\theta)$$

$$\left[\frac{m'}{M} v\right] = \frac{kg}{kg}\frac{m}{s} = \frac{m}{s^2}$$



F/M - g + mdot/M v sin(theta)

$\frac{F}{M} - g + \frac{\dot{m}}{M} \cdot v \cdot \sin(\theta)$ är korrekt.

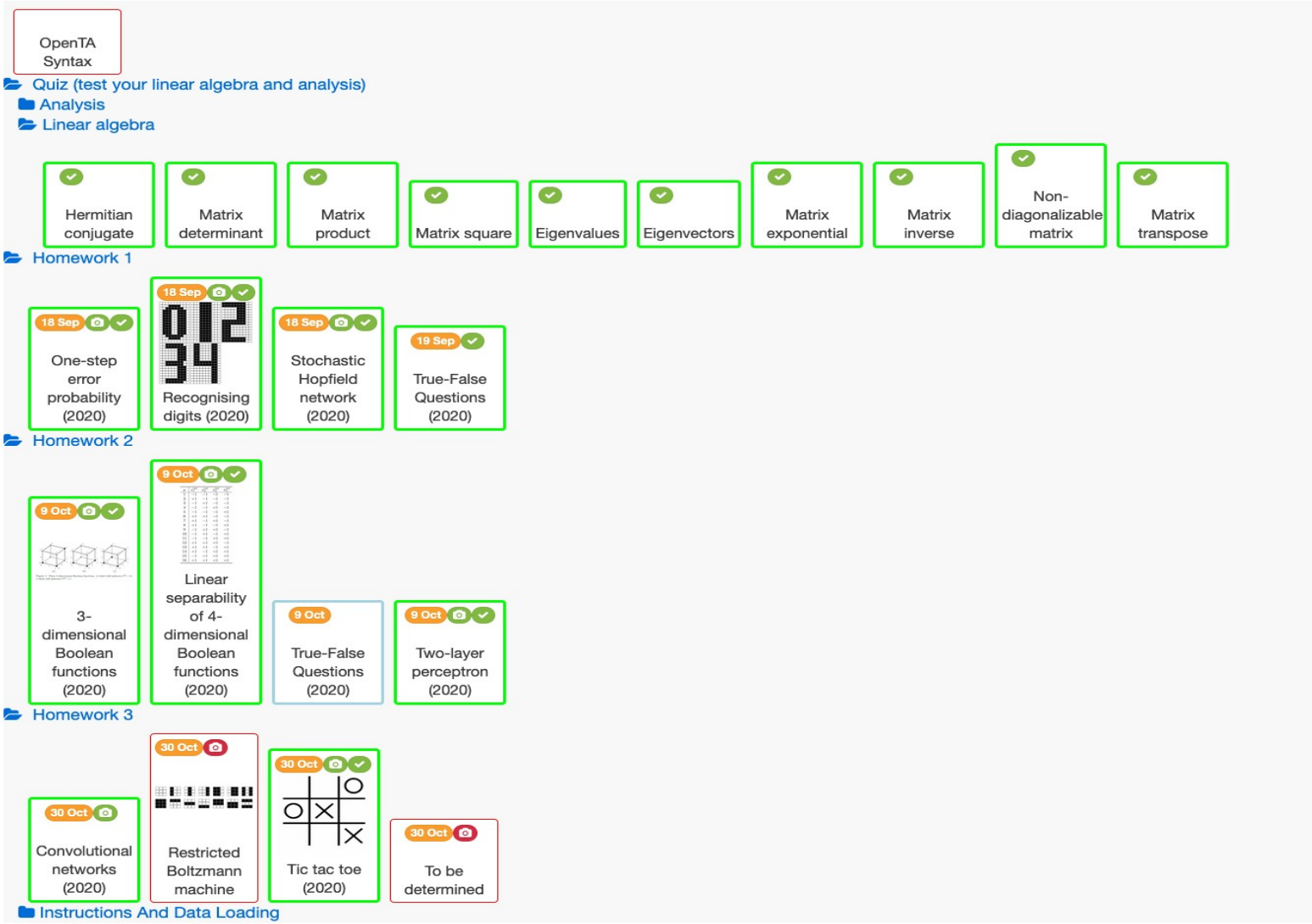
A A A

The following slide shows what a student's OpenTA page, from the Neural Networks course Bernhard Mehlig is teaching, might look like after a week or two.

We note now the embellishments on the icons. Questions are catgorised as ''Obligatory'' (blue) , "Bonus" (orange) or "Optional (no badge).

Due dates are listed, and green check mark indicates the answer was correct, and a green or red camera icon indicates an image was uploaded or missing.

Student can see their progress



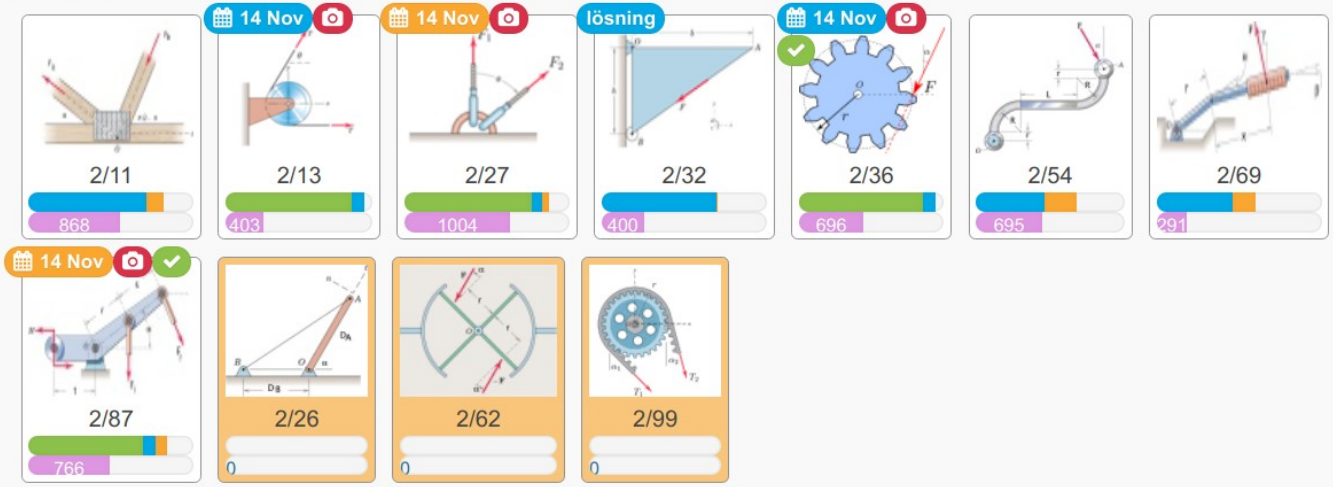
Student can see their progress

exercise name	date due	complete and ontime		autograded answers		image answers		Audit
OpenTA Syntax	no duedate	✗✗		✓✗	unanswered	✗✗	no image required	✗✗
Quiz (test your linear algebra and analysis)								
Analysis								
Linear algebra								
Hermitian conjugate	no duedate	✓✓	2020-09-02 at 08:24	✓✓	no deadline	✗✗	no image required	✗✓
Matrix determinant	no duedate	✓✓	2020-09-02 at 08:17	✓✓	no deadline	✗✗	no image required	✗✓
Matrix product	no duedate	✓✓	2020-09-02 at 08:19	✓✓	no deadline	✗✗	no image required	✗✓
Matrix square	no duedate	✓✓	2020-09-02 at 08:20	✓✓	no deadline	✗✗	no image required	✗✓
Eigenvalues	no duedate	✓✓	2020-09-02 at 08:20	✓✓	no deadline	✗✗	no image required	✗✓
Eigenvectors	no duedate	✓✓	2020-09-02 at 08:32	✓✓	no deadline	✗✗	no image required	✗✓
Matrix exponential	no duedate	✓✓	2020-09-02 at 08:50	✓✓	no deadline	✗✗	no image required	✗✓
Matrix inverse	no duedate	✓✓	2020-09-02 at 08:39	✓✓	no deadline	✗✗	no image required	✗✓
Non-diagonalizable matrix	no duedate	✓✓	2020-09-02 at 08:40	✓✓	no deadline	✗✗	no image required	✗✓
Matrix transpose	no duedate	✓✓	2020-09-02 at 08:44	✓✓	no deadline	✗✗	no image required	✗✓
Homework 1								
One-step error probability (2020)	2020-09-18 at midnight	✓✓	2020-09-06 at 10:26	✓✓	12 days early	✓✓	12 days early	✗✓
Recognising digits (2020)	2020-09-18 at midnight	✓✓	2020-09-05 at 12:48	✓✓	13 days early	✓✓	13 days early	✗✓
Stochastic Hopfield network (2020)	2020-09-18 at midnight	✓✓	2020-09-05 at 19:40	✓✓	13 days early	✓✓	13 days early	✗✓
True-False Questions (2020)	2020-09-19 at midnight	✓✓	2020-09-05 at 19:45	✓✓	14 days early	✗✗	no image required	✗✓
Homework 2								
3-dimensional Boolean functions (2020)	2020-10-09 at midnight	✓✓	2020-09-14 at 10:19	✓✓	25 days early	✓✓	25 days early	✗✓
Linear separability of 4-dimensional Boolean functions	2020-10-09 at midnight	✓✓	2020-09-14 at 09:32	✓✓	26 days early	✓✓	25 days early	✗✓
True-False Questions (2020)	2020-10-09 at midnight	✓✓		✓✓	unanswered	✗✗	no image required	✗✗
Two-layer perceptron (2020)	2020-10-09 at midnight	✓✓	2020-09-14 at 09:40	✓✓	25 days early	✓✓	25 days early	✗✓
Homework 3								
Convolutional networks (2020)	2020-10-30 at midnight	✓✓	2020-09-20 at 20:47	✓✗	unanswered	✓✓	40 days early	✗✓
Restricted Boltzmann machine	2020-10-30 at midnight	✗✗		✓✗	unanswered	✗✗	image missing	✗✗
Tic tac toe (2020)	2020-10-30 at midnight	✓✓	2020-09-18 at 22:36	✓✓	42 days early	✓✓	42 days early	✗✓
To be determined	2020-10-30 at midnight	✗✗		✓✗	unanswered	✗✗	image missing	✗✗
Instructions And Data Loading								

Teacher view.

The teacher sees essentially the same view as the student, but with some more badges on the exercise icon.

- Dynamik
- Statik
  - Intro v1
  - Statik v2

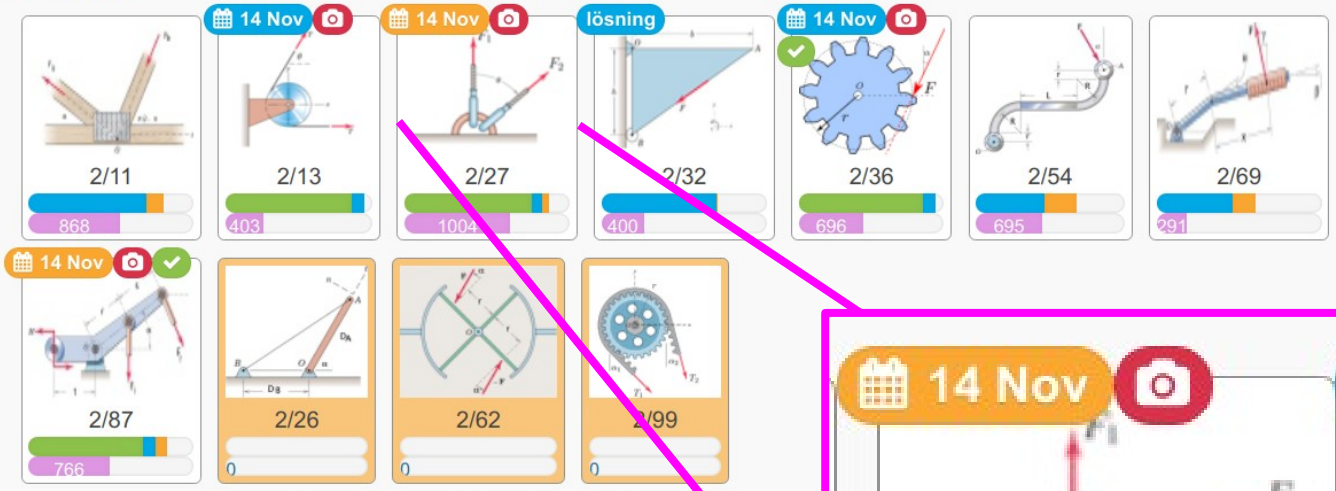


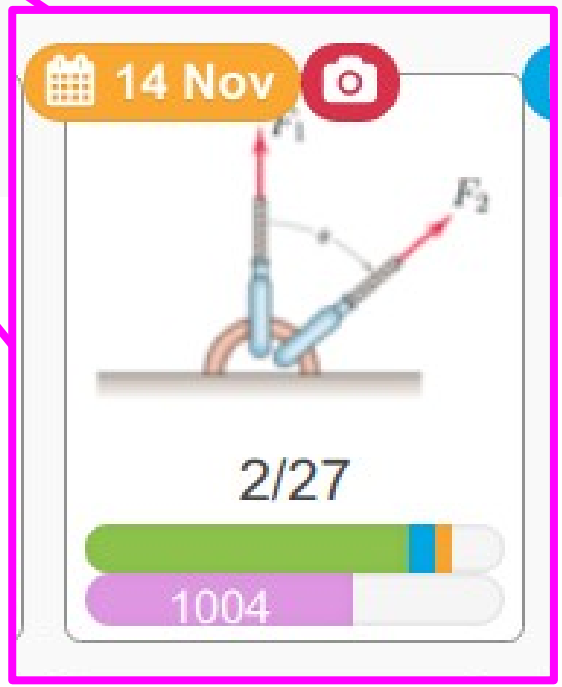
There are violet activity bar indicating how many student attempts there are on the particular question, green bar indicating how many have answered correctly and turned in their image, a blue bar indicating how many students have answered correctly, and an orange bar indicating how many students have tried but failed to answer the question.

The violet activity bar can be set to measure all activity, activity latest week, day or hour. Thus a teacher can see not only cumulative student progress but which questions are being worked on at at the time.

Dynamik
Statik

Intro v1
Statik v2





Recently submitted answers can also be read, and not only the latest, but also a number of tried attempts the student tried. The teacher can thereby find out common mistakes that students might be making.

STATIK V2

2/11

14 Nov 2/13

14 Nov 2/27

lösning 2/32

14 Nov 2/36

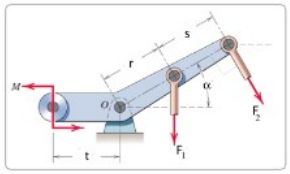
2/54

Saved

2/87

Deadline: 14 Nov 08:00 Bonus

Systemet givet av kraftparet M samt krafterna F_1 och F_2 kan ersättas med en resulterande kraft med en given verkningslinje. (**Antag att** $F_1 > 0, F_2 > 0$). Beräkna vridmomentet M samt storleken på resultanten av systemet givet att verkningslinjen för resultanten passerar genom O.



R (i termer av F1, F2, r, s, alpha)

sqrt(F1^2+F2^2+2*F1*F2*cos(alpha))

$\sqrt{F_1^2 + F_2^2 + 2 \cdot F_1 \cdot F_2 \cdot \cos(\alpha)}$ är korrekt.

M (positiv riktning enligt figur) (i termer av F1, F2, r, s, alpha)

r * F1 * cos(alpha) + (r + s) * F2

$r \cdot F_1 \cdot \cos(\alpha) + (r + s) \cdot F_2$ är korrekt.

Recent answers

$\sqrt{(F1 + F2\ \cos(\alpha))^2 + (F2\ \sin(\alpha))^2}$

$\sqrt{F1^2 + F2^2}$

$F1 + F2$

$r \cdot (F1 \cdot \cos(\alpha) + F2) + s \cdot$

$-F2 \cdot (r + s) - r \cdot F1 \cdot \cos$

[redacted]

$F1 + F2 \cdot \cos(\alpha) + F2 \cdot \sin(\alpha)$

[redacted]

$(r + s) \cdot F2 + r \cdot \cos(\alpha) \cdot F$

[redacted]

$\sqrt{F1^2 + F2^2 + 2 \cdot F1 \cdot F2 \cdot \cos(\alpha)}$

$\sqrt{2 \cdot F2^2 + 4 \cdot F1 \cdot F2 \cdot (\sin(\alpha) + \cos(\alpha)) + F1^2}$

$\sqrt{F1^2 + F2^2}$

[redacted]

$-(r + s \cdot (\frac{F2}{F1})) \cdot \sqrt{(F2)^2 +$

$(r + s \cdot (\frac{F2}{F1})) \cdot \sqrt{(F2)^2 + ($

$-(r + s \cdot (\frac{F2}{F1})) \cdot \sqrt{(F2)^2 +$

$-(r + s \cdot (\frac{F1}{F2})) \cdot \sqrt{(F2)^2 +$

$r \cdot \sqrt{(F2)^2 + (F1)^2 + 2 \cdot F$

[redacted]

$\left(F1 \cdot r \cdot \sin(\alpha) + F2 \cdot \left(\frac{((r+s) \cdot \sin(\alpha))}{\cos(\alpha)}\right)\right)$

$F \cdot \left(r \cdot \sin(\alpha) + \left(\frac{((r+s) \cdot \sin(\alpha))}{\cos(\alpha)}\right)\right)$

$r \cdot \sin(\alpha) + \left(\frac{((r+s) \cdot \sin(\alpha))}{\cos(\alpha)}\right)$

$\cos(\alpha) \cdot F2 + F1 + \sin(\alpha) \cdot F2$

[redacted]

$(r + s) \cdot F2 + F1 \cdot r \cdot \cos(\alpha$

More detail about a particular exercise is availble. The time that submissions were made, typically hitting a peak just before deadline.

Late submissions are never rejected, they are always just marked late so the teacher has an option to accept them if they are feeling generous.

Exercise file path: Stochastic Hopfield network 2019

Stochastic Hopfield network (2020)

Deadline: 18 Sep 23:59 Bonus

Write a computer program implementing a Hopfield network using Hebb's rule with $w_{ii} = 0$, and asynchronous stochastic updating with $p(b) = \frac{1}{1+\exp(-2\beta b)}$ with the noise parameter $\beta = 2$. Use your computer program to answer the questions below.

Use $N = 200$ neurons and store $p = 7$ random patterns $\underline{x}^{(\mu)}$ ($\mu = 1, \ldots, p$). Each bit $x_i^{(\mu)} = \pm 1$ with probability $\frac{1}{2}$. Feed the stored pattern $\underline{x}^{(1)}$ to the network and perform $T = 2 \cdot 10^5$ asynchronous stochastic updates.

Estimate the resulting order parameter $m_1(T)$. Repeat this experiment 100 times. Each experiment should be initialised by a new realisation of independently drawn random patterns. Average $m_1(T)$ over the experiments to obtain $\langle m_1(T) \rangle$.

To obtain credits for this task, you must upload the computer code you used to get all results you enter below, in PDF format. Use the upload button at the top of this page. All PDF files you upload here must also be combined into a single PDF file and submitted to URKUND, before the deadline (see instructions in General information).

What is the value of $\langle m_1(T) \rangle$ for $T = 2 \cdot 10^5$, $p = 7$, $N = 200$, and $\beta = 2$? State your result using three decimal places.

[0 attempts]

0.878

0.878

Repeat the above task, but for $p = 45$. All other parameters are the same.

What is the value of $\langle m_1(T) \rangle$ for $T = 2 \cdot 10^5$, $p = 45$, $N = 200$, and $\beta = 2$? State your result using three decimal places.

[0 attempts]

0.138

0.138

Statistics

240/326 tried this exercise.

73.6%

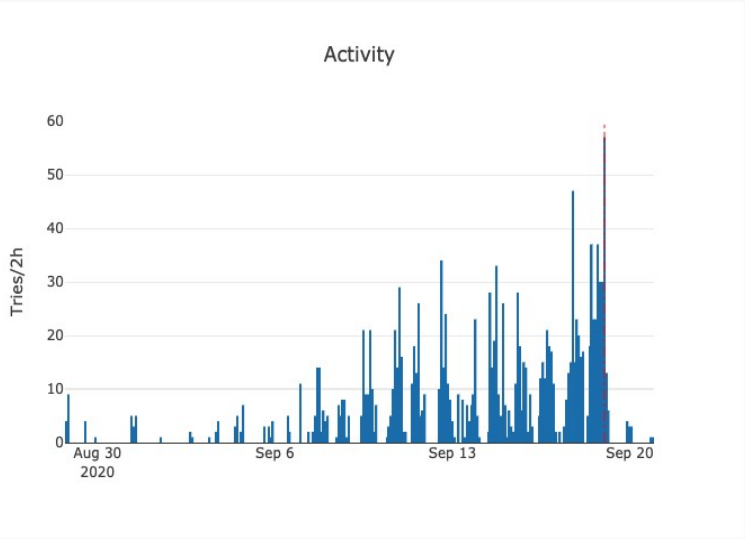
234/326 answered correctly.

71.8%

232/326 complete (correct before deadline).

71.2%

2.0 attempts per question (median)



The examiner can also ”audit” the student responses. I.e. go throught the student answers and uploads and override the automatic settings generated by the computer. We typically use this as spot-checks on the student submissions. In the next slide, a student submission is shown togher with comments to be transmitted to the student.

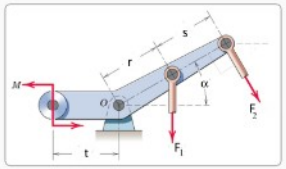
An exercise is accepted on the basis of a correct answer and a submitted image unless there is intervention by an audit by TA or teacher. Several TA’s can share the task of auditing exercises.

Add audit 4 / 4 1 2 3 4

2/87

Deadline: 14 Nov 08:00

Bonus



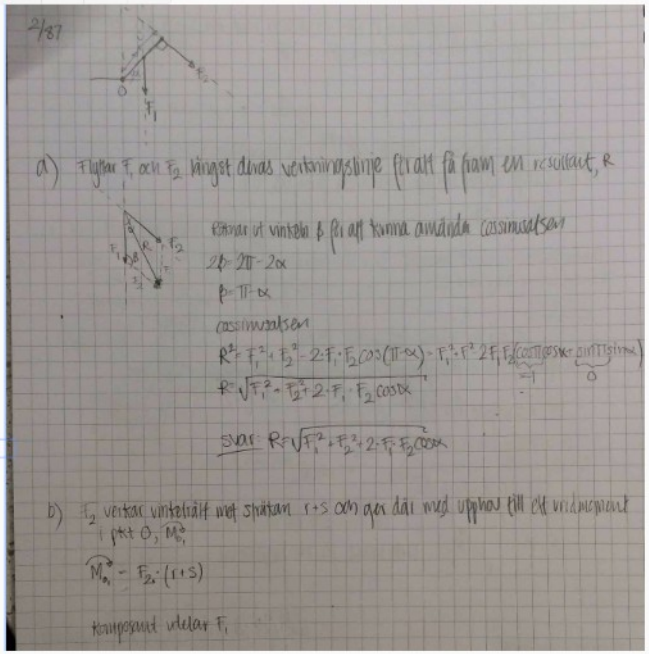
Systemet givet av kraftparet M samt krafterna F_1 och F_2 kan ersättas med en resulterande kraft med en given verkningslinje. (**Antag att** $F_1 > 0$, $F_2 > 0$). Beräkna vridmomentet M samt storleken på resultanten av systemet givet att verkningslinjen för resultanten passerar genom O.

R (i termer av F1, F2, r, s, alpha)

sqrt(F1^2+F2^2+2*F1*F2 *cos(alpha))

$\sqrt{F_1^2 + F_2^2 + 2 \cdot F_1 \cdot F_2 \cdot c}$ är korrekt.

Solution image: 1/1 2016-11-13 19:47



R

$\sqrt{F1^2 + F2^2 + 2\ F1\ F2\ \cos($

M **(positiv riktning enligt figur)**

$F2\,(r+s) + F1\,r\ \cos(\alpha)$

$F2\,(r+s) + F1\,r\ \cos(\alpha)$

$-F2\,r\,s - F1\,r\ \cos(\alpha)$

$F2\,r\,s + F1\,r\ \cos(\alpha)$

Bra lösning men tänk på att alltid ställe upp vad som är sökt och givet samt att göra en enhets- och rimlighetsanalys.

Send Delete

Other messages

Finally grade sheets showing who has done completed how many questions.

Filters

Text search

Filter on name and usern

Obligatory deadline

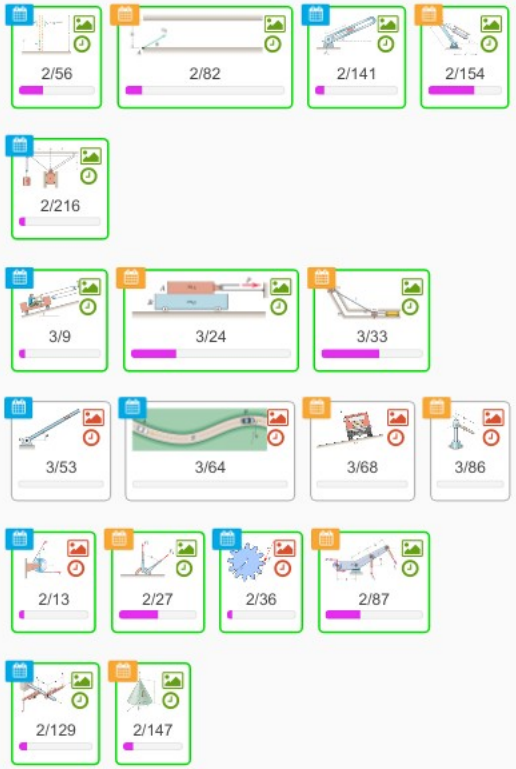
- No deadline
- Answer
- Answer & Image

Bonus deadline

- No deadline
- Answer
- Answer & Image

Username	Obligatory	Bonus	Optional	Late	Total
[redacted]	16	15	41	(1)	72
	0	0	5	(0)	5
	7	0	21	(4)	28
	16	16	20	(0)	52
	16	15	42	(0)	73
	13	16	28	(0)	57
	15	16	19	(1)	50
	12	0	6	(0)	18
	6	2	26	(22)	34
	0	0	0	(0)	0
	15	13	8	(2)	36
	16	6	13	(1)	35
	16	13	27	(0)	56
	16	16	44	(0)	76
	16	9	6	(0)	31
	16	16	37	(0)	69
	8	2	8	(8)	18
	16	16	22	(0)	54
	16	0	15	(0)	31
	12	4	18	(0)	34
	16	16	15	(0)	47

[redacted] All Graded Optional



A teacher can also examine students work by entering OpenTA as that student. This is useful if an individual is having difficulties with either the physics or the OpenTA technology.

Back to list

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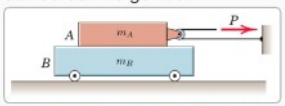
Deadline: 30 Jan 08:00

Bonus

Den statiska och dynamiska friktionskoefficienten mellan blocken är μ. Om P är tillräckligt stor kommer blocken att glida mot varandra. Beräkna blockens acceleration både i fallet då de glider och då de inte gör det.



Dold för studenter. Visa för studenter genom att klicka i "solution" i inställningarna.

Lösning

a_A när blocken glider (i termer av mu, ma, mb, P, g)

(-mu*ma*g+2*P)/ma

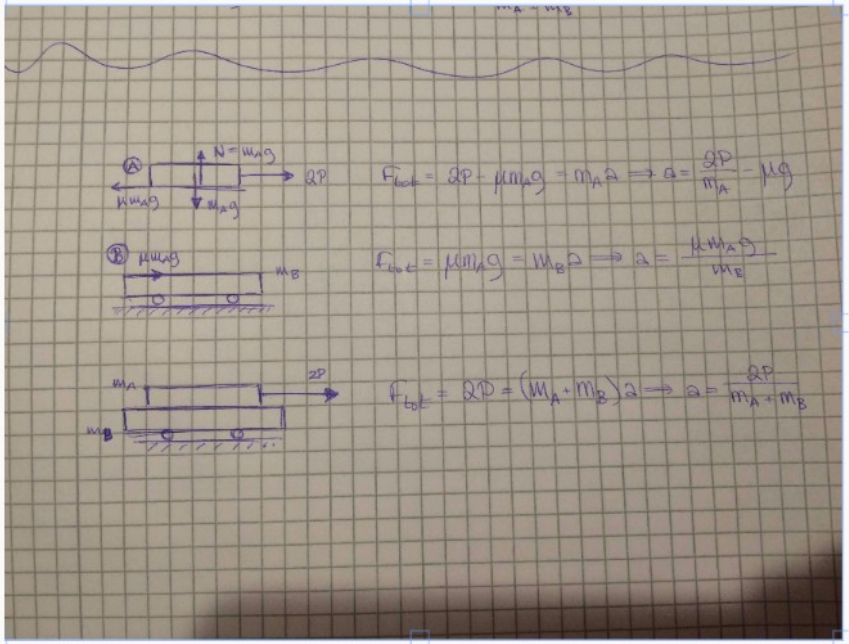
$\frac{(-\mu \cdot ma \cdot g+2 \cdot P)}{ma}$

A A A

a_B när blocken glider (i termer av mu, ma, mb, P,

[redacted]

Solution image: 1/1 2017-01-26 13:52



a_A när blocken glider

- $\frac{2P}{ma} - \mu g$
- $\frac{2P}{ma} - \mu$
- $\frac{2P}{ma} - \mu$

a_B när blocken glider

- $\frac{\mu ma g}{mb}$
- $\frac{(2P+\mu ma g)}{(ma)}$
- $\frac{(2P+\mu ma g)}{(ma+mb)}$
- $\frac{(2P-\mu ma g)}{(ma+mb)}$
- $\frac{2P}{(ma+mb)} - \left(\frac{2P}{ma} - \mu g\right)$
- $\frac{2P}{(ma+mb)} - \frac{\mu g}{mb}$

a när blocken inte glider

- $\frac{2P}{(ma+mb)}$
- $\frac{P}{(ma+mb)}$
- $P \cdot (ma + mb)$

The OpenTA client, i.e. where the screen shots come from, is a ”desktop app” written in Javascript using React.

The OpenTA server is based on Django, a framework based on Python3.

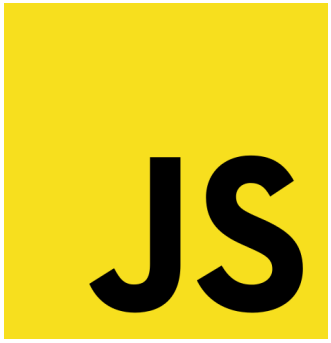
All packages are OpenSource.

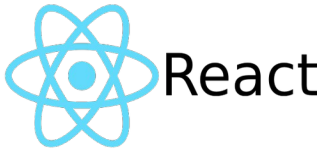
Canvas and Moodle can be configured to use OpenTA as a tool.

Client

Server

LMS





OpenTA is designed as a learning tool, not as an examination tool. We encourage collaboration and trying answers multiple times.

Thus, we have not limited the number of responses and make no attempts to ”lock down” access to other media. We do find, however that students work very hard for ”Bonus” points and that has turned out to be an important motivation for the students to take the exercises seriously.

The following courses at Chalmers and GU have used OpenTA.

The opinions from both teachers and students who have used OpenTA has been overwhelmingly positive.

Courses at GU and Chalmers

FFM516	Mekanik 1
FFM521	Mekanik 2
FFY143	Fysik 2
LFY073	Fortbildning fysiklärare
FKA081	Quantum mechanics
FFM234	Vektorfält och klassisk fysik
FIM770	Dynamical systems
FYP102	Mekanik A
FIM720	Neural networks
FFY012	Fasta tillståndets fysik
LGFY10	Fysik för gymnasielärare

OpenTA

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