Exam
Mechanics & Relativity 2017–2018 (part Classical Mechanics)
November 23, 2017

INSTRUCTIONS

- This exam comprises 4 problems. Start your solution of each problem on a separate sheet.
- Write the name of your tutor and/or group on the top right-hand corner of the first sheet handed in, and *drop your work in the box with your tutor's name.*
- The first is a set of three conceptual multiple-choice questions, for which only the answer matters not your arguments. The answers to problems 2 through 4 require clear arguments and derivations, all written in a well-readable manner.
- The number of points for every subquestion are indicated inside a box in the margin. The total number of points per problem is

Problem	# of points
1	3
2	5
3	5
4	7

and the grade is computed as (total # points) $/20 * 9 + 1$.

Problem 1 Below are three conceptual multiple-choice questions. Only the answer (A ... E) matters, not your arguments.

a. The figure depicts Three identical masses are constrained to move on a hoop with Three identical springs.

How many normal modes will there be?

A) 0
B) 1
C) 2
D) 3
E) 4

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b. Inside the international space station the astronauts will sleep in order to maintain their biological clock. Which of the following statements are correct ?

A) Upward
B) Downward
C) Any orientation
D) Attach themselves
E) None of them are true

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c. You are in a spaceship accelerating upwards with a constant acceleration $a_{spaceship}$ relative to earth but far from Earth so that there is negligible gravity. You drop a penny inside the spaceship. Which of the following statements are correct?

A) An observer on earth says that the penny goes downward with a constant velocity
B) You say the penny accelerates upwards with respect to you: $a_{penny/you} = -a_{spaceship}$
C) An observer on earth says that the penny is accelerated upwards with a constant acceleration $a_{spaceship}$
D) You say that the penny is moving downward with a constant velocity
E) You view that there is a fictitious Force being acted on the penny

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The answers to problems 2 through 4 require clear arguments and derivations, all written in a well-readable manner.

Problem 2 An international space station weighs an initial mass m. A fixed upward thrust N is required to keep it at a constant hight from the surface of the earth. One fine morning, Engineers at NASA observe that the space station starts to move downward towards earth with a constant acceleration w. In order to maintain the same upward thrust N and reach the same upward acceleration w, an astronaut *inside* the space station has decided to dump mass Δm into the space. Show that the dumped mass will be given by:

$$\Delta m = \frac{2mw}{g+w},$$

where g is the Earth's gravitational acceleration acting downward radially. Assume that the air drag is zero. 5

Problem 3 A horizontal disc rotates with a constant angular velocity ω about a vertical axis passing through its centre. A small body of mass m moves along a diameter of the disc with a velocity v which is constant relative to the disc. Determine the magnitude and direction of each and every force that the disc exerts on the body at the moment when it is located at the distance r from the rotation axis. 5

Problem 4 Two identical masses are constrained to move on a circle. Two identical springs connect the masses and wrap around a circle. see Figure below.

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Find the normal frequencies.