

EXAM 1
203-NYA-05 — Mechanics

Winter 2017
Prof: Jean-Raphaël Carrier

Name:

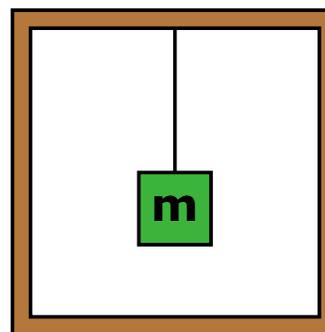
Instructions

- For questions 1 to 7, only the correct answer(s) is(are) needed.
 - For questions 8 to 12, clearly expose every step of your solution. Points will be awarded to sketches, explanations and calculations, not only to the final values.
 - Be precise in all your calculations: the first three digits in the final value must be correct for an answer to be considered valid. Units are also mandatory.
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Question 1 [3 points]

A block of mass $m = 10 \text{ kg}$ is suspended to a massless cable inside a wooden crate. Although the crate is located near Earth's surface (thus $g = 9.8 \text{ m/s}^2$), the tension inside the cable is only 85 N . How can that be explained?

- a) The box is moving downward at a constant speed.
- b) The box is moving upward at a constant speed.
- c) The box is accelerating downward.
- d) The box is accelerating upward.
- e) Both a) and c) could explain the situation.
- f) Both b) and d) could explain the situation.



Question 2 [3 points]

We know that, when a projectile lands at the same height it was thrown, the maximum range (without friction) is obtained at an initial angle of 45° . If we want to throw a projectile from a higher point (relative to where it will land), the initial angle giving the maximum range is. . .

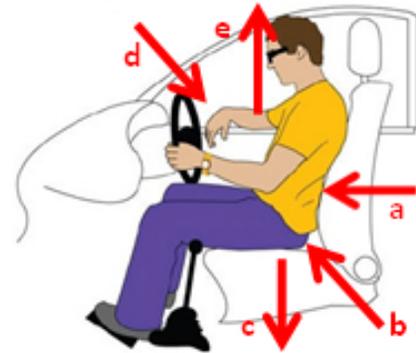
- a) . . . smaller than 45° .
- b) . . . still equal to 45° .
- c) . . . larger than 45° .
- d) . . . smaller or larger, it depends on how much higher we start.

Note: the angles are given relative to the horizontal.

Question 3 [6 points]

A 70-kg driver accelerates from rest at 9.8 m/s^2 .

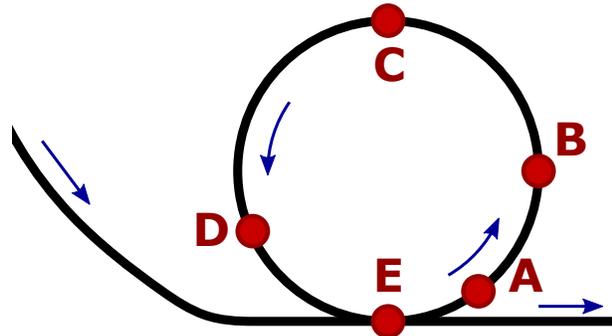
- a) [3 pts] Which vector correctly represents the direction of the normal force exerted by the seat on the driver?
- b) [3 pts] What is the magnitude of this normal force?
 - i) 0 N
 - ii) 686 N
 - iii) 970 N
 - iv) 1372 N



Question 4 [6 points]

A roller coaster goes through a circular loop. In the part shown, no motor is used (the velocity is thus not constant) and friction can be neglected.

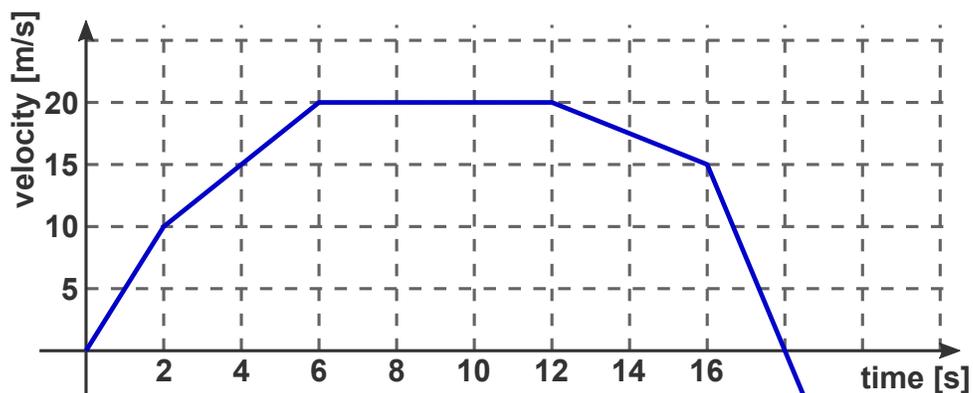
- a) [3 pts] Circle the point (letter) where the magnitude of the centripetal acceleration is maximum.
- b) [3 pts] On the figure, show the direction of the total acceleration at point D.



Question 5 [3 points]

The velocity of an object moving in a straight line is shown. If the object is at position $x = 125 \text{ m}$ at $t = 8 \text{ s}$, where was it at $t = 0 \text{ s}$?

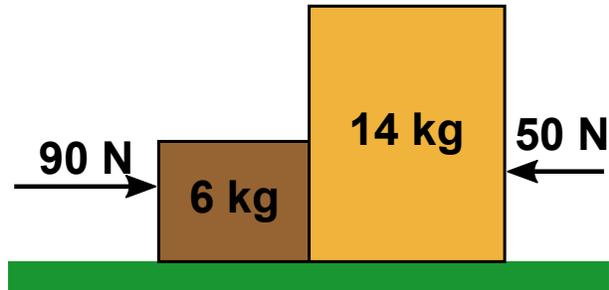
Answer: $x_0 =$



Question 6 [3 points]

What is the magnitude of the normal force **between the two boxes** in the following situation. *There is no friction.*

- a) $F_N = 40 \text{ N}$
- b) $F_N = 50 \text{ N}$
- c) $F_N = 78 \text{ N}$
- d) $F_N = 90 \text{ N}$
- e) $F_N = 98 \text{ N}$
- f) $F_N = 140 \text{ N}$



Question 7 [6 points]

A puck having a weight of 6 N is attached via a massless string to a suspended weight of 2 N. *There is no friction.*

a) [2 pts] Which expression correctly represents the tension force (F_T) inside the string?

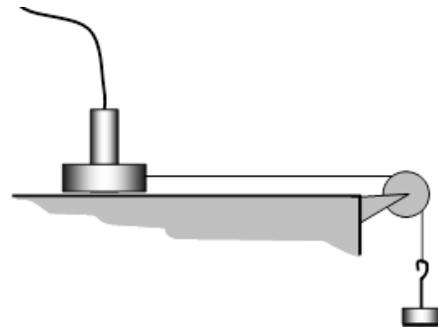
- i) $F_T < 2 \text{ N}$
- ii) $F_T = 2 \text{ N}$
- iii) $F_T = 6 \text{ N}$
- iv) $F_T > 6 \text{ N}$

b) [2 pts] Which expression correctly represents the magnitude of the acceleration of the suspended weight?

- i) $a < 9.8 \text{ m/s}^2$
- ii) $a = 9.8 \text{ m/s}^2$
- iii) $a > 9.8 \text{ m/s}^2$

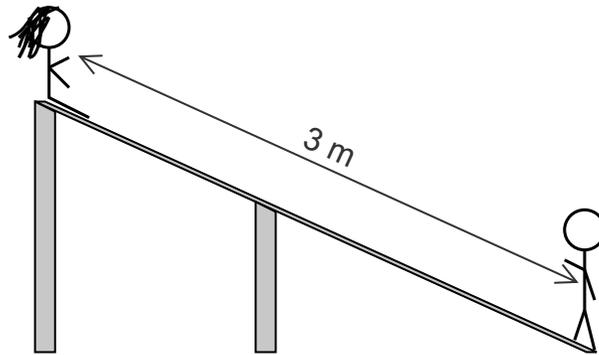
c) [2 pts] If we increase the mass of the puck (by placing stuff on it, for example), what will happen to the tension force inside the string?

- i) It will decrease
- ii) It will not change
- iii) It will increase



Question 8 [15 points]

Caillou and Mousseline are playing without supervision on a 3-m long slide. Exactly when Caillou (the bald kid) starts walking up the slide with a constant speed of 0.4 m/s , his sister lets herself go down from the top (no initial speed, constant acceleration of 0.8 m/s^2).



a) [10 pts] When and where will they collide?

b) [5 pts] How long would it have taken Mousseline to reach the bottom of the slide if her brother had not been in her way?

Question 9 [15 points]

During a tumultuous Super Bowl, Tom Brady throws the football from a height of 2 m with a velocity of 21 m/s at 32° above the horizontal. . . yet nobody completes his pass.

- a) [9 pts] At what horizontal distance from Tom Brady does the football hit the ground?
- b) [6 pts] What is the maximum height reached by the football during its flight?

Question 10 [15 points]

During her driving test, an apprentice driver makes a completely legal U-turn (180° turn). She was initially not going very fast ($v_i = 10 \text{ m/s}$), but since it is her exam she decides to slow down anyway, with a constant tangential deceleration of 1 m/s^2 during the U-turn. On the whole, the U-turn took 5 s to complete.

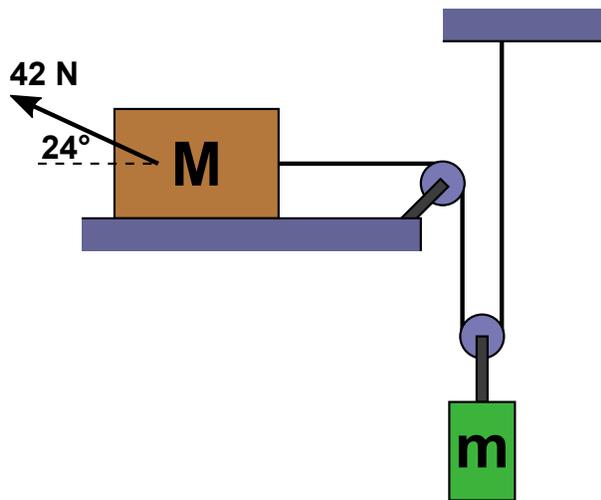
- a) [3 pts] At what speed did she complete her U-turn?
- b) [4 pts] What is the radius of curvature of the U-turn?
- c) [4 pts] What is the centripetal acceleration of the car halfway through the U-turn?
- d) [4 pts] What is the total acceleration (magnitude and orientation) halfway through U-turn?
Draw a sketch to show the orientation and give a precise angle.

Question 11 [15 points]

A wooden box ($M = 15 \text{ kg}$) is connected via a massless rope and massless pulleys to a suspended block ($m = 5 \text{ kg}$). Someone pulls the wooden box with a constant force of 42 N at 24° , as shown below. *All forms of friction can be neglected.*

- a) [5 pts] Calculate the normal force between the wooden box and the horizontal surface.
- b) [5 pts] Calculate the tension inside the rope.
- c) [5 pts] Calculate the acceleration of the suspended block.

Hint: The two objects do not have the same acceleration.



Question 12 [10 points]

A truly lost Captain Charles Patenaude lands on a planet whose diameter is 8000 km. From the surface of this planet, Patenaude throws a small rock vertically into the air. It took exactly 4.5 s for the rock to reach a maximum height of 15 m and fall back into the captain's hands.

What is the mass of the planet?

Answers

1. c 2. a 3. a) b b) iii 4. a) E 5. 15 m 6. c 7. a) i b) i c) iii
8. a) 2.284 s later, 2.086 m from Mousseline's starting point b) 2.739 s
9. a) 43.43 m b) 8.318 m
10. a) 5 m/s b) 11.937 m c) 5.236 m/s^2 d) 5.331 m/s^2 at 100.8° relative to her velocity, toward the inside of the curve
11. a) 129.92 N b) 25.57 N c) 0.4267 m/s^2
12. $1.421 \cdot 10^{24} \text{ kg}$