EXAM 2

203-NYA-05 — Mechanics

Winter 2017 **Name:**

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Instructions

- For questions 1 to 10, only the correct answer(s) is(are) needed.
- For questions 11 to 14, 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.

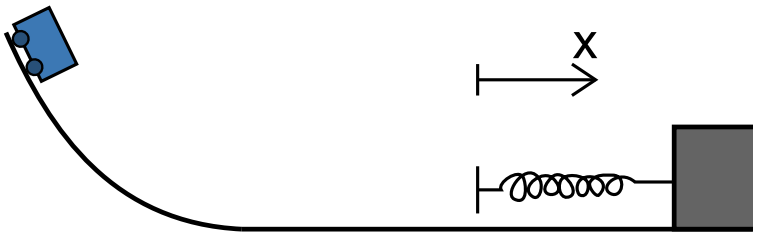
Question 1 [3 points]

We let go a small cart from the top of a frictionless slope. At the bottom of the slope, the cart is stopped by a zone where surface friction is important. If we do the same experiment with two carts of different masses ($m_b = 4\,m_a$), what can be said of the distance they travel on the zone with friction before they come to rest?

a) $d_b < d_a$ **b)** $d_b = d_a$ **c)** $d_b = 2\,d_a$ **d)** $d_b = 4\,d_a$

Question 2 [3 points]

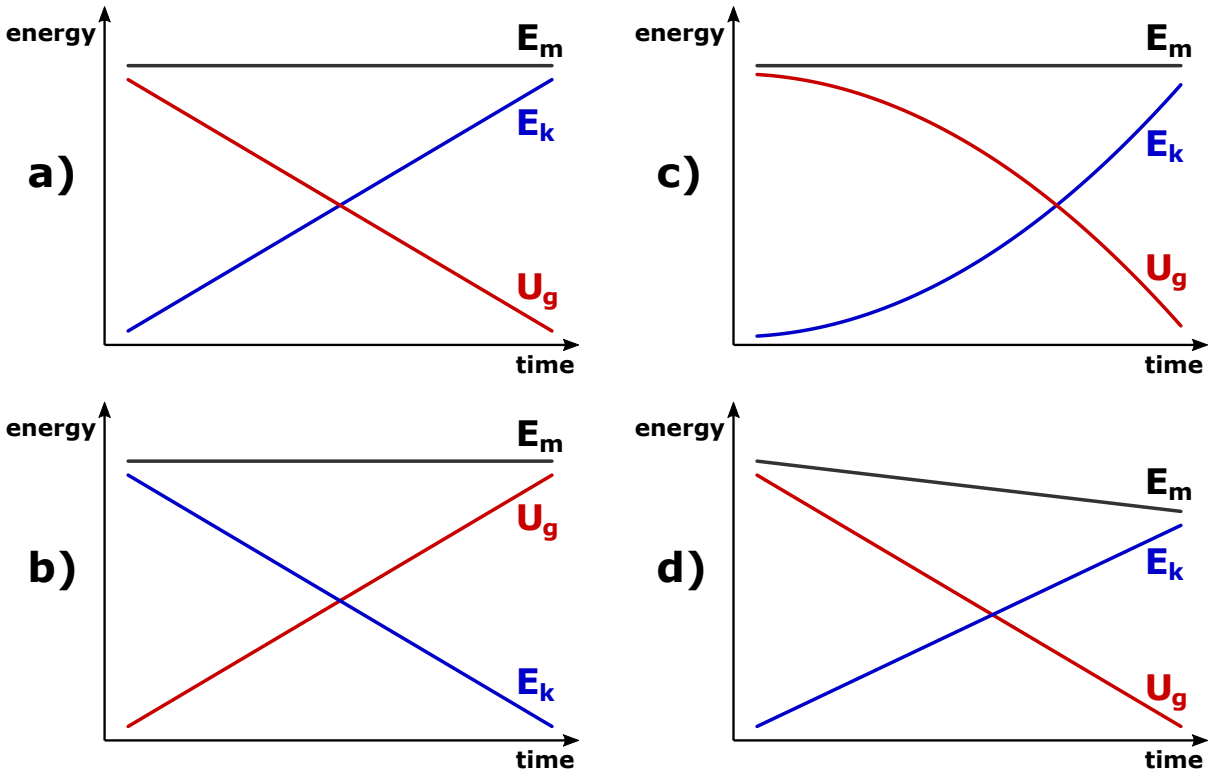
We let go a small cart from the top of a frictionless slope. At the bottom of the slope, the cart is stopped by a spring. If we do the same experiment with two carts of different masses ($m_b = 4\,m_a$), what can be said of the maximum compression of the spring?



a) $x_b < x_a$ **b)** $x_b = x_a$ **c)** $x_b = 2\,x_a$ **d)** $x_b = 4\,x_a$

Question 3 [3 points]

A block slides down an inclined plane without friction. Which of the following graphs correctly represents the mechanical, kinetic and potential energies of the block?



Question 4 [3 points]

Jean-Raphaël takes one ping-pong ball and one baseball, and simultaneously drops them from the same height. He observes that the baseball hits the ground before the ping-pong ball does.

Which of the following statements is(are) true? *Circle every correct answer.*

a) The drag force on the baseball is smaller than the one applied on the ping-pong ball.

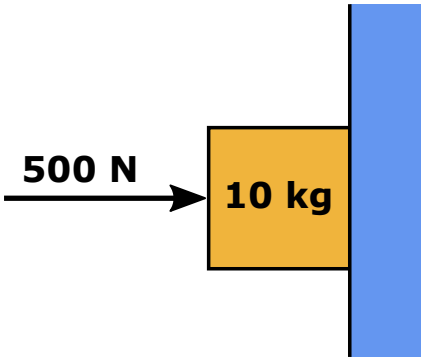
b) The buoyancy force on the baseball is smaller than the one applied on the ping-pong ball.

c) The gravitational force on the ping-pong ball is smaller than the one applied on the baseball.

d) The net force on the ping-pong ball is smaller than the one applied on the baseball.

Question 5 [3 points]

A block is pushed against a vertical wall by a horizontal force of 500 N. The coefficient of static friction is $\mu_s = 0.25$ and the coefficient of kinetic friction is $\mu_k = 0.2$. What is the maximum additional mass that can be placed onto the block before it starts to slip?

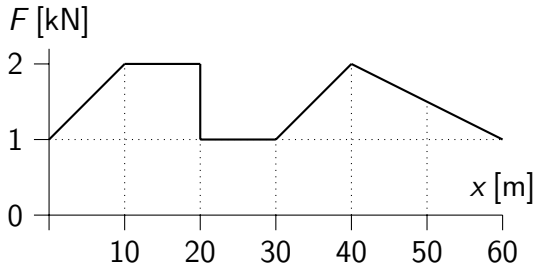


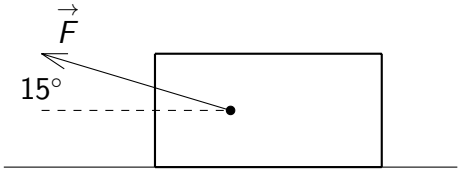
Answer: $m_{\text{max}} =$

Question 6 [3 points]

Egyptian workers are pulling a huge 1250-kg block to bring it to a pyramid in construction. They apply a pulling force at 15° relative to the horizontal. The value of that force is shown on the graph below. What is the work done by the workers over that distance of 60 m?

Answer: $W =$





Question 7 [3 points]

A loonie is placed on a horizontal rotating disk, at 30 cm from the axis of rotation. The coefficients of kinetic and static friction are respectively $\mu_k = 0.1$ and $\mu_s = 0.15$. If the disk rotates at a constant speed of 120° per second...

a) ...the loonie remains at 30 cm from the axis of rotation.

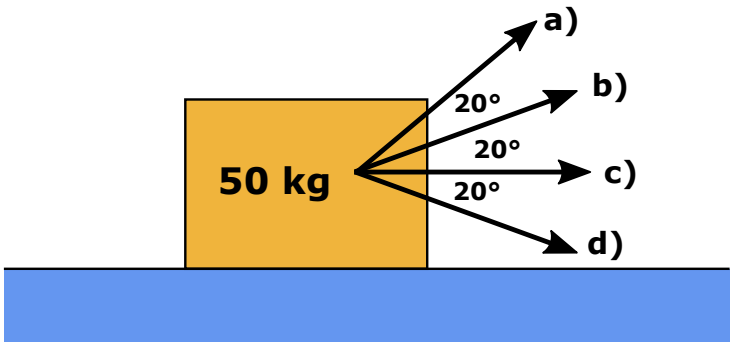
b) ...the loonie slides outward.

c) ...the loonie slides inward.

d) It is impossible to know whether it slides or not without knowing its mass.

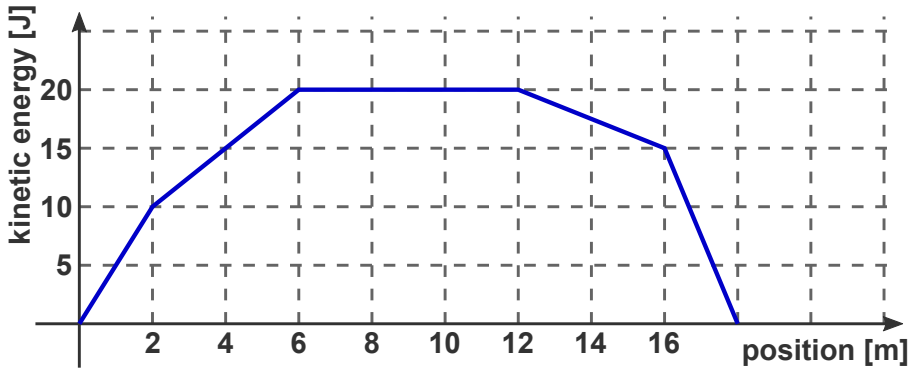
Question 8 [3 points]

The coefficient of kinetic friction between the box and the floor is 0.3. Which of these tension forces (they all have the same value of $F_T = 300\,\text{N}$) will provide the greatest horizontal acceleration to the block?



Situation for questions 9 and 10

A block moves from $x = 0\,\text{m}$ to $x = 18\,\text{m}$ in a situation where the mechanical energy of the block is constant (no loss nor gain in mechanical energy). The following graph illustrates the kinetic energy of the block with respect to its position.



Question 9 [3 points]

What is the net work applied on the block during this displacement?

Answer: $W_{net} =$

Question 10 [3 points]

What is the direction of the net force applied on the block when it is at $x = 4\,\text{m}$?

a) The net force is toward the negative x axis.

b) The net force is zero.

c) The net force is toward the positive x axis.

d) It is impossible to know with the provided information.

Question 11 [20 points]

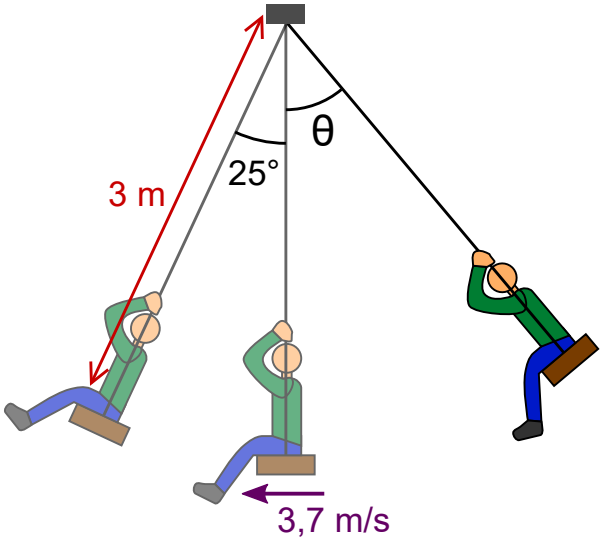
A child plays on a swing. At first, he starts from the angle θ with no initial speed. At his lowest point, he has a speed of 3.7 m/s. The child and the swing have a combined mass of 30 kg and their centre of mass lies at 3 m from where the two ropes of the swing are attached.

a) [7 pts] From what initial angle θ did the child start his motion?

b) [5 pts] What is the force of tension inside each of the two ropes when the child is at his lowest position? *(We can assume that the tension is the same in each rope.)*

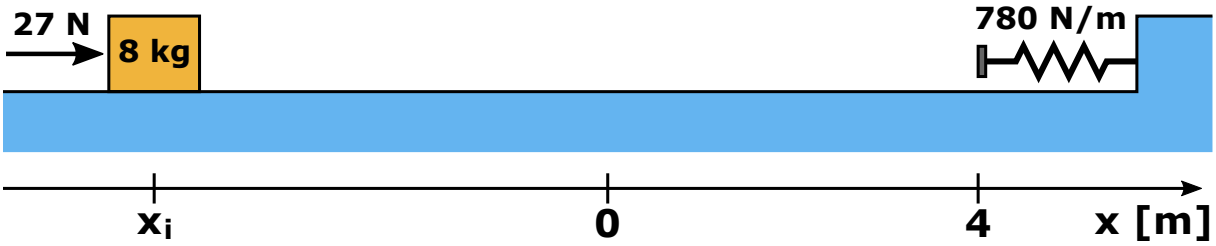
c) [5 pts] What is the number of g's felt by the child at his lowest position?

d) [3 pts] On the figure, draw the vector of the apparent weight when the child is at the position shown on the left (angle of 25°) and still going forward.



Question 12 [20 points]

From positions $x = x_i$ to $x = 0$, a person pushes an 8-kg box toward the right with a constant force of 27 N. At position $x = 0$, exactly when the box has a speed of 5 m/s, the person stops pushing. From there, the box slides until it bounces off a spring of constant $k = 780\,\text{N/m}$, then slides toward the left before finally coming to a stop. During the whole process, the coefficient of kinetic friction between the box and the horizontal surface is $\mu_k = 0.2$.



a) [5 pts] What is the initial position x_i? *(It should be a negative value.)*

b) [5 pts] What is the speed of the box just before it touches the spring?

c) [5 pts] What is the maximum compression of the spring?

d) [5 pts] At what position does the box finally comes to a stop?

Question 13 [15 points]

Brad Spitfire has been dropped on a small foreign planet by the crew of the Romano Fafard. This planet has a mass of $9 \cdot 10^{21}$ kg, a radius of 400 km and it does one complete rotation every 95 min. Brad (60 kg) is standing on the equator.

a) [6 pts] What is the value of Brad's apparent weight?

Wanting some help, Brad designs a satellite (850 kg) to call for help.

b) [5 pts] At which distance from the surface of the planet should this satellite be placed if Brad wants the satellite to be directly above him at all times? *(Geostationary orbit.)*

c) [4 pts] How much mechanical energy would be required to bring the satellite to that orbit?

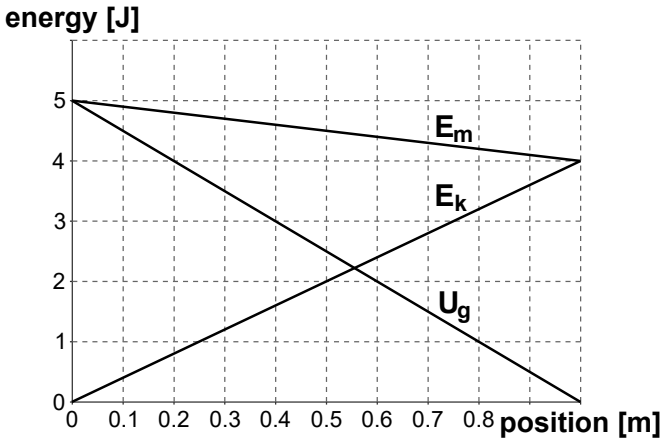
Question 14 [15 points]

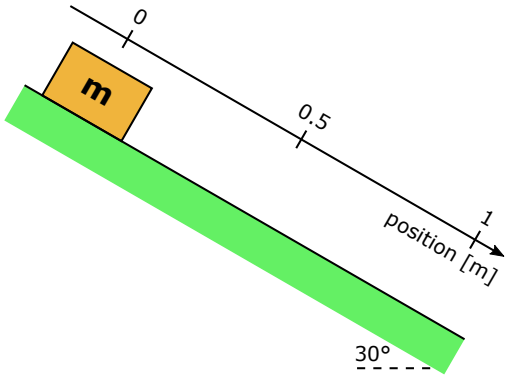
A block slides down an inclined plane making an angle of 30° relative to the horizontal. The graph below shows the mechanical energy of the block relative to its position along that slope.

a) [5 pts] What is the mass of the block?

b) [5 pts] What is the coefficient of kinetic friction between the block and the slope?

c) [5 pts] What is the acceleration of the block?





Answers

1. b 2. c 3. c 4. c-d 5. 2.755 kg 6. 86 933 J 7. a 8. b

9. 0 J 10. c

11. a) 39.90° b) 215.45 N c) 1.4656 d) $\vec{w}_{\text{app}}$ points at 245° (toward the bottom left, aligned with the rope of the swing)

12. a) −8.834 m b) 3.053 m/s c) 28.97 cm d) 2.202 m

13. a) 196.09 N b) 390.69 km c) $3.153 \cdot 10^8$ J

14. a) 1.0204 kg b) 0.1155 c) 3.92 m/s^2