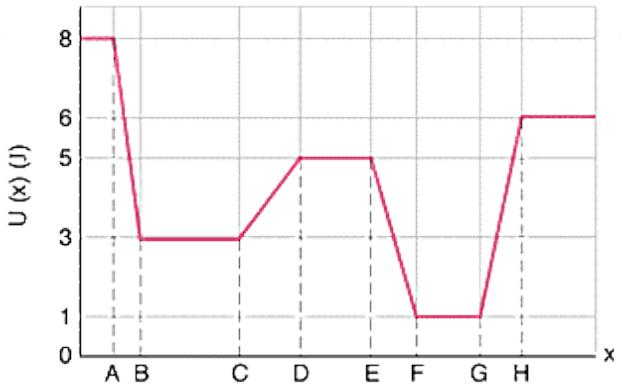
EXAM #3

MECHANICS
40% of the final grade

Winter 2017 Name: _____

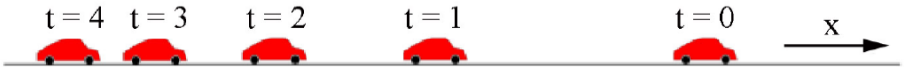
Questions 1 to 15 are worth 2 points each. Only the answers are corrected.

1. Here is the graph of the potential energy of an object with respect to its position. The mechanical energy of the object is constant. Initially, the object is motionless at $x = A$. Where is the object when the net force applied on it is the greatest while being directed toward the negative x axis?



a) Between A and B.
b) Between B and C.
c) Between C and D.
d) Between D and E.
e) Between E and F.
f) Between F and G.
g) Between G and H.

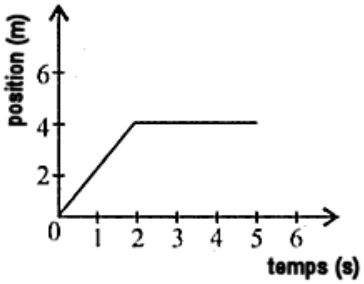
2. The following figure shows a car's position at different times.



Which of the following statements is true?

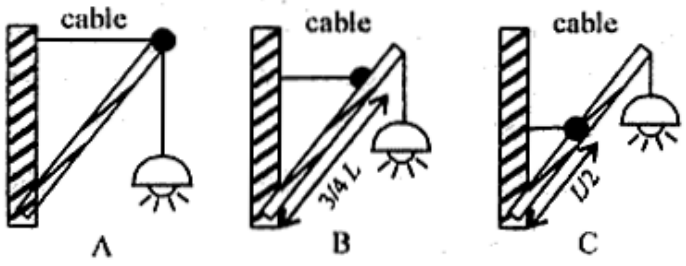
a) The car's velocity and acceleration are both positive.
b) The car has a positive velocity and a negative acceleration.
c) The car has a negative velocity and a positive acceleration.
d) The car's velocity and acceleration are both negative.

3. The graph on the right shows the position of a 10-kg object with respect to time. What is the value of the impulse applied on the object between $t = 0$ s and $t = 5$ s?



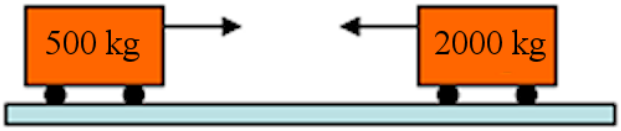
Answer: _____

4. A lamp is suspended at the end of a long rod, the rod being attached to the wall at its other extremity by a pivot. The rod is maintained in static equilibrium by a horizontal cable. In which of these three cases is the tension force inside the cable the greatest?



a) A.
b) B.
c) C.
d) It is the same tension force in all three cases.

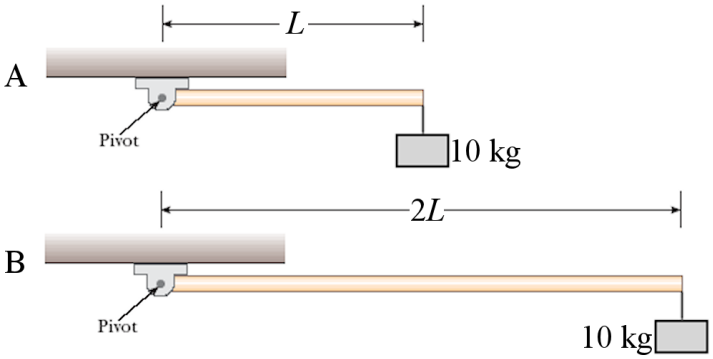
5. Two carts rolling toward each other make a perfectly inelastic collision.



If the two carts initially had the same kinetic energy, in which direction will they go after the collision?

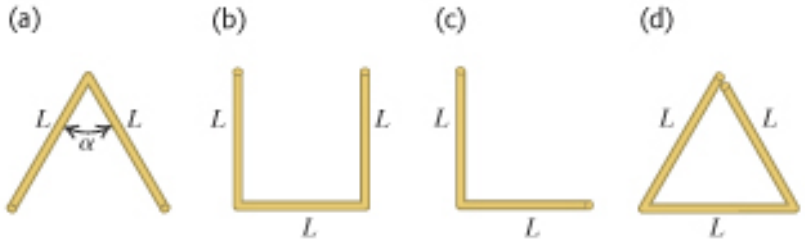
a) Toward the right.
b) Toward the left.
c) They will not move at all.

6. Assuming that both rods are massless, which rod experiences the greatest angular acceleration?



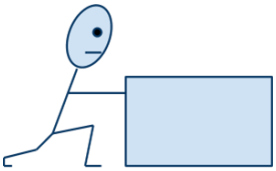
a) A.
b) B.
c) Both rods experience the same angular acceleration.

7. Sort the following objects according to the height of their centre of mass, from the highest centre of mass to the lowest. ($\alpha = 60°$)

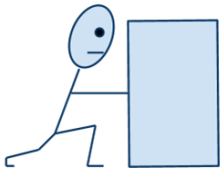


Answer: _____

8. Mathieu wants to push a box on a horizontal surface using a horizontal force. In which orientation must he place the box to have the smallest friction force possible? *Assume that the box will slide without tumbling.*



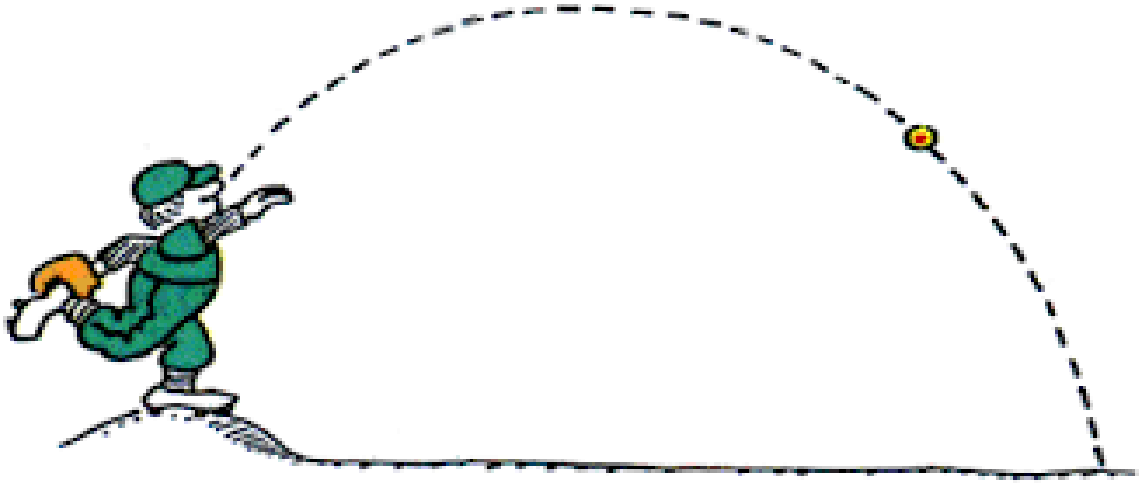
Orientation 1



Orientation 2

a) Orientation 1.
b) Orientation 2.
c) The friction force will be the same in both cases.

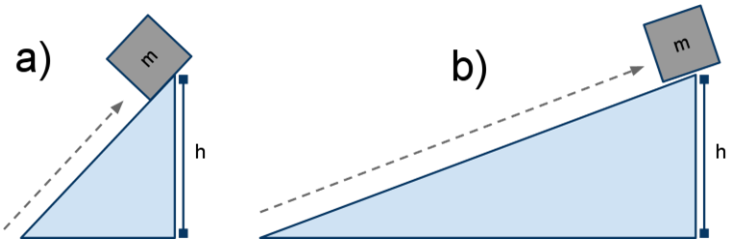
9. On the figure, draw two vectors, one indicating the direction of the velocity of the ball and another to illustrate the direction of its acceleration. Name your vectors $\vec{v}$ and $\vec{a}$.



10. Marilyn goes skydiving. At one point before opening her parachute, she is falling at a constant speed. On the figure, draw a vector illustrating the direction of Marilyn's apparent weight at this instant.

- It's a trap, her apparent weight is zero.

11. Ann-Julie wants to move a heavy box up a slope at constant speed. She has the choice between a steep slope and a gentle slope.



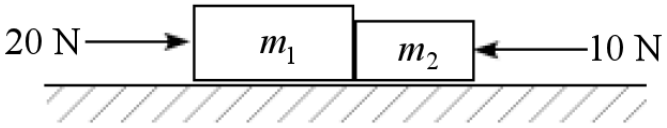
Which slope must she use to minimize the work required to move the box up, assuming there is no friction?

a) The work required is smaller with the steeper slope.
b) The work required is smaller with the gentler slope.
c) The work required is the same in both cases.

12. Anne-Sophie stands in the centre of a rotating platform (no friction). At first, she has her arms stuck against her body; the platform and Anne-Sophie then rotate with a combined rotational kinetic energy of E_k. If Anne-Sophie extends her arms as much as possible, the rotational kinetic energy of the system will…

a) … increase.
b) … stay the same.
c) … decrease.

13. Two forces are exerted in opposite directions on two blocks of unknown masses. There is no friction.



The value of the contact force between the two blocks is…

a) … greater than 30 N.
b) … equal to 30 N.
c) … between 20 N and 30 N.
d) … equal to 20 N.
e) … between 10 N and 20 N.
f) … equal to 10 N.
g) … between 0 N and 10 N.
h) … zero since there is no friction.

14. During a vacation in Russia, Mireille drops a stone into Lake Baikal, which is a very deep lake (the deepest in the world). The stone sinks and, at some point, its speed stops increasing. When that happens, the sum of all the forces applied on the stone (gravitational force, drag force and buoyant force) is…

a) … directed upward.
b) … equal to zero.
c) … directed downward.

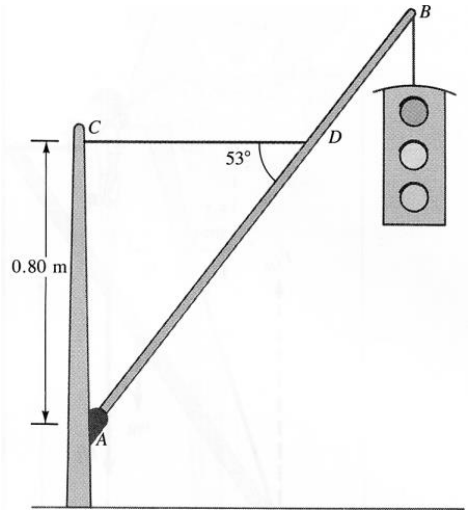
15. A car makes a turn on a non-inclined horizontal road at a constant speed. Assuming that the drag force (air resistance) can be neglected, draw a vector indicating the direction of the static friction force exterted by the road on the car. *At this instant, the car is moving toward the left while turning to its left.*

- It's a trap, there is no friction force.

For questions 16 to 21, the complete solutions are required. Points will be awarded (or deducted) for sketches, graphs, calculations and units, not only for the final answers.

16. (10 points)

A 10-kg traffic light is suspended at the end of an aluminum rod maintained by a horizontal massless cable *CD* and a frictionless pivot in point *A*. The aluminum rod has a length of 1.5 m and a mass of 5 kg.



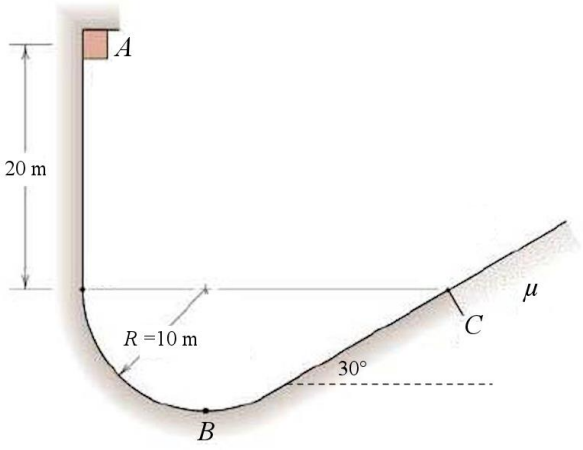
a) Calculate the tension force inside the massless cable *CD*.

b) Calculate the force exerted by the pivot *A* on the rod (magnitude and direction).

17. (15 points)

A 10-kg small block is released with no initial speed from point *A*. There is no friction between *A* and *C*, but the surface beyond point *C* has a coefficient of kinetic friction equal to 0.5.

a) What is the speed of the block at point *B*?
b) What is its acceleration at point *B*?
c) What is the number of *g*'s felt by the block at point *B*?
d) What is the speed of the block at point *C*?
e) What distance will the block travel beyond point *C*?



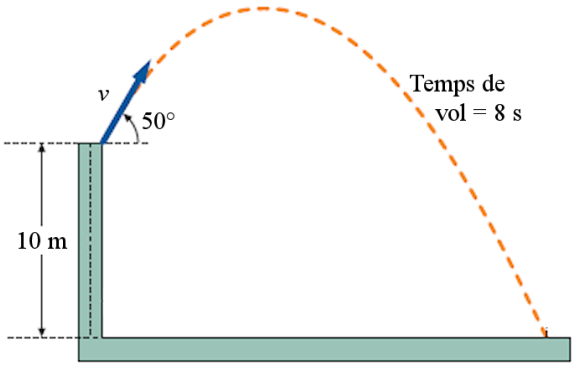
18. (20 points)

Jean-Raphaël is driving at 50 km/h when he sees an obstacle located 20 m in front of his car. Jean-Raphaël takes 0.5 s to react and push the breaks. Luckily, he breaks without sliding with just enough force to stop just before the obstacle. *For your calculations, assume that the acceleration is constant and that the mass of the car (Jean-Raphaël included) is 1200 kg.*

a) What is the car's acceleration during the breaking phase?
b) How much time has elapsed from the time Jean-Raphaël saw the obstacle to the time where he stopped completely?
c) What is the net work applied on the car during the breaking phase?
d) What is the minimum coefficient of static friction required to break like this?
e) At what speed (in km/h) would Jean-Raphaël have collided with the obstacle if he had been driving at 60 km/h? *Assume the same reaction time and the same acceleration in the breaking phase as previously.*

19. (15 points)

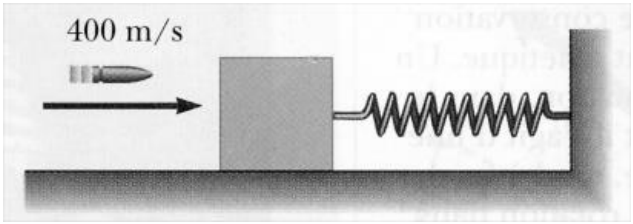
A 10-kg cannonball is shot as indicated on the figure on the right, which is not to scale. The cannonball reaches the ground 8 s later. *Assume that there is no drag force.*



a) What is the initial speed of the projectile?
b) What is the maximum height reached by the projectile, with respect to the ground?
c) At what horizontal distance from the cliff does the cannonball reach the ground?
d) At what time has the cannonball reached a height of 5 m above the ground?
e) What is the work applied by the gravitational force on the projectile during its flight?

20. (15 points)

A 30-gram bullet initially moving at 400 m/s hits and stays inside a 2-kg wooden block. The block is fixed to a wall by a spring (initially at rest) of constant 100 N/m.



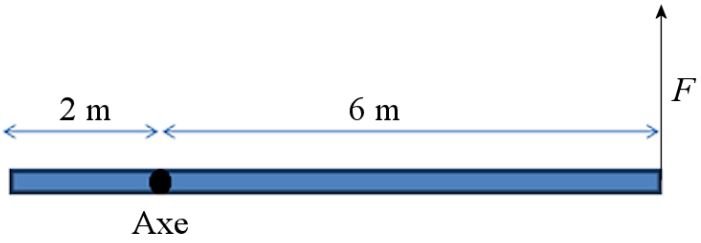
a) Without friction, what would be the maximum compression of the spring?

b) With a coefficient of kinetic friction of 0.8, what would be the maximum compression of the spring?

c) What is the acceleration of the block (magnitude and direction) when the compression of the spring is equal to half the maximum compression? Consider the case with friction.

21. (15 points)

A 8-m long, 6-kg uniform rod can rotate without friction about the stationary axis shown on the right. A perpendicular 10-N force is applied at one extremity. The rod is initially motionless. *The rod is seen from above, so you do not have to consider the effect of the gravitational force.*



a) What is the angular acceleration of the rod?
b) How many rotations will the rod have completed during the first 10 seconds?
c) What is the speed of the long extremity of the rod when t = 10 s?
d) What is the kinetic energy of the rod when t = 10 s?
e) What is the average power applied by the 10-N force during the first 10 seconds?

Answers

1. g 2. c 3. –20 kg m/s 4. c 5. b 6. a

7. a-b-d-c 8. c

9. $\vec{v}$ is tangential to the path (toward the bottom right), $\vec{a}$ points downward

10. $\vec{w}_{app}$ points downward 11. c 12. c 13. e 14. b

15. $\vec{F}_f$ points toward the centre of the circle

16. a) 138.23 N b) 201.78 N at 46.76°

17. a) 24.25 m/s b) 58.8 m/s² c) 7 d) 19.80 m/s e) 21.44 m

18. a) –7.388 m/s² b) 2.38 s c) –115.7 kJ d) 0.75385 e) 36.96 km/h

19. a) 49.54 m/s b) 83.48 m/s c) 254.75 m d) 7,874 s e) 980 J

20. a) 84.22 cm b) 69.80 cm c) 25.03 m/s² toward the left

21. a) 1.0714 rad/s² b) 8.526 rotations c) 64.29 m/s d) 3214 J e) 321.4 W