EXAM 3

MECHANICS

40% of the final grade

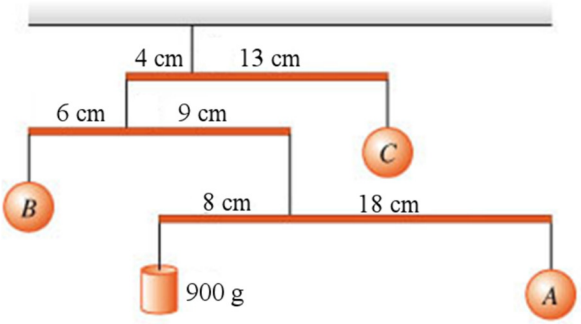
Winter 2018 Name:_____

Each multiple-choice question is worth 2 marks.

1. The mass of the two wheels shown in the diagram is the same. A force of 1 N is exerted on the edge of the small wheel to give it some angular acceleration. What force F_2 must be exerted on the edge of the large wheel so that two wheels have the same angular acceleration? (You can approximate by considering that the wheels are rings.)

- ❑ F_2 must be smaller than 1 N
- ❑ F_2 must be 1 N
- ❑ F_2 must be larger than 1 N

2. Which one of these objects has the smallest mass if this system is in equilibrium?

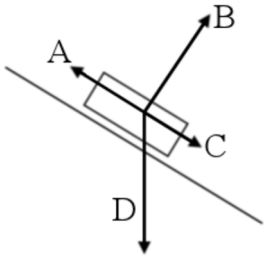


- ❑ A
- ❑ B
- ❑ C
- ❑ The 900 g object
- ❑ All the masses are identical.

3. Two balls are dropped from the same height. The mass of ball A is twice as large as the mass of ball B. Which ball has the greatest kinetic energy just before hitting the ground if there is no friction?

- ❑ Ball A
- ❑ Ball B
- ❑ They have the same kinetic energy.

4. A block slides uphill on a slope after being thrown by Tamilyn. Which of these vectors correctly shows the direction of the net force acting on the block as it slides uphill? (Tamilyn does not touch the block at this time.)

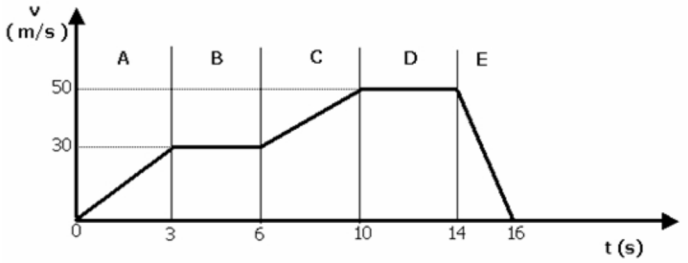


- ❑ A
- ❑ B
- ❑ C
- ❑ D
- ❑ None of these vectors

5. In which of the following situation(s) is the net force zero on the object? (Check all cases where the net force is zero.)

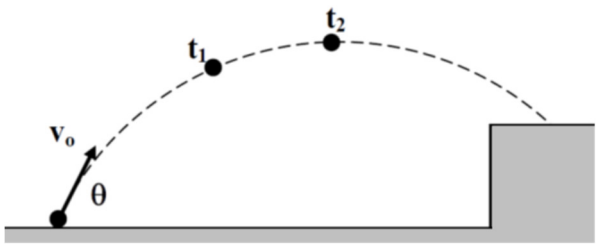
- ❑ A pendulum that passes at the lowest point of its trajectory.
- ❑ A pendulum that reached its maximum height.
- ❑ A stone thrown directly upwards that reached its maximum height.
- ❑ An astronaut in the international space station in orbit around the Earth.
- ❑ A skydiver who has reached its terminal velocity.

6. This graph shows the speed of an object as a function of time. During which interval is the displacement of the object the largest?



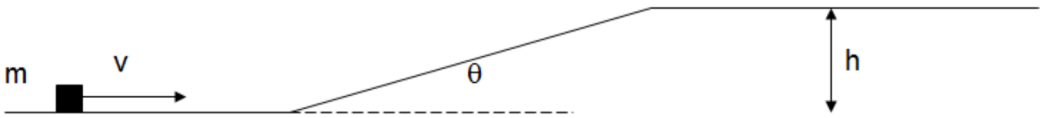
- ❑ A
- ❑ B
- ❑ C
- ❑ D
- ❑ E

7. The diagram shows the position of a projectile at two different instants t_1 and t_2. The velocity at time t_1 is $\vec{v}_1$ and the velocity at time t_2 is $\vec{v}_2$. What is the direction of the vector $\vec{v}_2 - \vec{v}_1$ if there is no air friction?



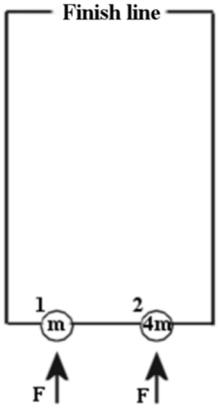
- ❑ Upwards ↑
- ❑ Downwards ↓
- ❑ Downwards and to the right ↘
- ❑ Upwards and to the right ↗

8. A block slides towards a ramp. When it arrives at the top of the slope, the block has a speed of 5 m/s. If there is no friction, how will the speed of the block at the top of the slope change if the angle is decreased (but the height *h* stays the same)?



- ❑ It is smaller than 5 m/s.
- ❑ It is equal to 5 m/s.
- ❑ It is larger than 5 m/s.

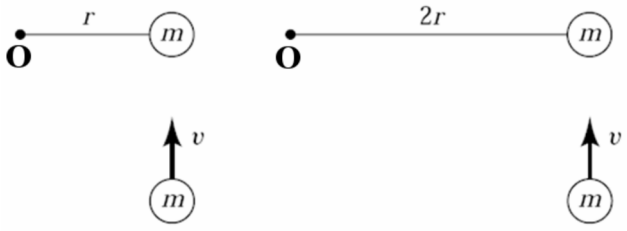
9. The following diagram shows 2 pucks on a frictionless table. Puck 2 is 4 times more massive than puck 1. Starting from rest, the two pucks are pushed from one side of the table to the other by forces of the same magnitude. Which puck has the largest momentum at the finish line if there is no friction?



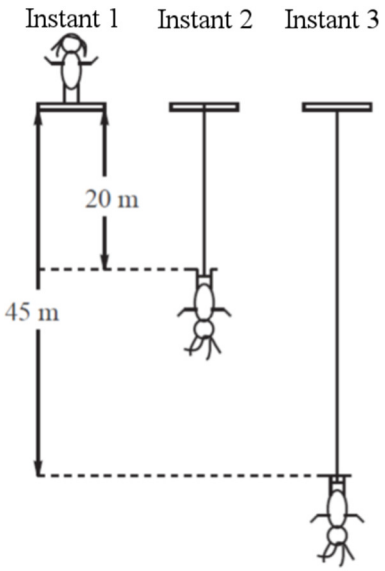
- ❑ Puck 1.
- ❑ Puck 2.
- ❑ They have the same momentum.

10. A mass m strikes another identical mass at rest. This other mass is attached to a rope of length r, which is firmly fixed to the ground at its other end (point O). After a perfectly inelastic collision, the combined mass at the end of the rope rotates with a certain angular velocity around the point O. If the length of the rope is increased so that it is twice as long (as shown on the diagram to the right), then the angular velocity after the collision…

- ❑ will be 4 times smaller.
- ❑ will be 2 times smaller.
- ❑ will be the same.
- ❑ will be 2 times larger.
- ❑ will be 4 times larger.



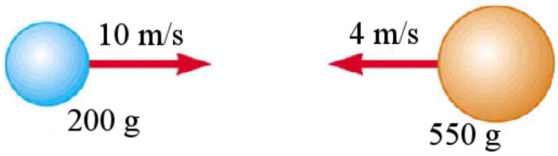
11. Christina goes bungee-jumping. The diagram shows Christina's position at 3 different moments. At instant 2, the rope begins to stretch while Christina reaches its lowest position at instant 3. What are the signs of the work done by the rope and by gravity between instants 2 and 3?



- ❑ The work by the rope and by gravity are both positive.
- ❑ The work by the rope and by gravity are both negative.
- ❑ The work done by the rope is negative and the work done by gravity is positive.
- ❑ The work done by the rope is positive and the work done by gravity is negative.

12. There is a collision between two balls. Which ball undergoes the biggest change of momentum during the collision (in absolute value)?

- ❑ The 200 g ball
- ❑ The 550 g ball
- ❑ The change is the same for both balls.



13. In the situation shown in the image, the car is travelling at its minimum speed so that it doesn't slip down the wall. Which force(s) provide(s) the centripetal force? Note that the wall is not completely vertical. (Say if it is the total force or only a component of the force that provides the centripetal force. Do this for all the forces if there is more than one.)

Answer(s):

_____

_____

_____

14. A formula 1 takes a turn as shown on the image on the right. Draw a vector showing the direction of the apparent weight of the pilot at this time.

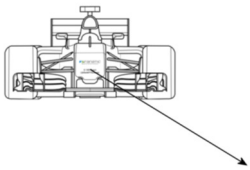
15. Victoria and Lori-Ève are both trying to move a big box. They are pushing very hard but the boxes do not move. Victoria and Lori-Ève exert exactly the same force, and the box that Victoria tries to push is more massive. The coefficient of static friction between the boxes and the ground is the same in both cases. In which case is the frictional force between the ground and the box the greatest?

- The friction is greater on the box that Victoria is trying to push.
- The friction is the same on both boxes.
- The friction is greater on the box that Lori-Ève is trying to push.

Answers: 1c 2a 3a 4c 5e 6d 7b 8b 9c 10b 11c 12c 15b

13 A component of the normal force

14.



16. (12 points)

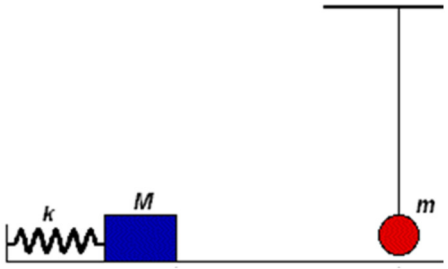
A rocket starts from rest and moves horizontally on a frictionless track. The engine of the rocket work for 10 seconds by ejecting 20 kg of gas per second at a speed of 400 m/s. Initially, the rocket has a mass of 250 kg (including the fuel). Once the engine has stopped, the rocket makes a perfectly inelastic collision with a huge block of Styrofoam at rest. The mass of the block is 300 kg.

a) What is the thrust force of the engine?
b) What is the speed of the rocket before the collision?
c) What is the speed of the Styrofoam block, with the rocket embedded inside, after the collision?
d) After the collision, the Styrofoam block (with the rocket) slides on the ground. How far will the block travel if the coefficient of kinetic friction between the ground and the block is 0.4? (Neglect air friction.)

Answers: a) 8000 N b) 643.78 m/s c) 91.968 m/s d) 1078.8 m

17. (12 points)

In the situation shown in the diagram, the masses are $M = 5$ kg and $m = 1$ kg, and the spring constant is 500 N/m. The initial compression of the spring is 150 cm. Then, the mass M is released. This mass then makes an elastic collision with a pendulum. There is no friction between the mass M and the ground and there is no air friction.

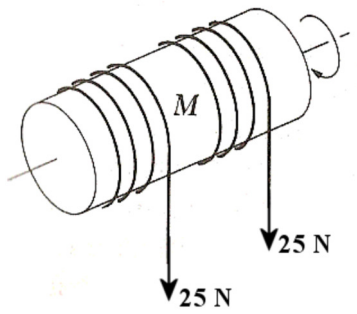


a) What is the speed of mass M after it has been pushed by the spring?
b) What is the speed of mass m after the collision?
c) What is the maximum angle reached by the pendulum after the collision if the rope is 60 m long?
d) When the pendulum returns to the vertical after having reached its maximum angle, what is the tension of the rope?

Answers: a) 15 m/s b) 25 m/s c) 62.06° d) 20.2 N

18. (12 points)

Two strings are wound around a cylinder that can rotate without friction around a fixed axis. The radius of the cylinder is 30 cm. Initially, the cylinder does not rotate. When a person exerts a constant force of 25 N on each string, the cylinder makes 10 complete rotations in 4 seconds.

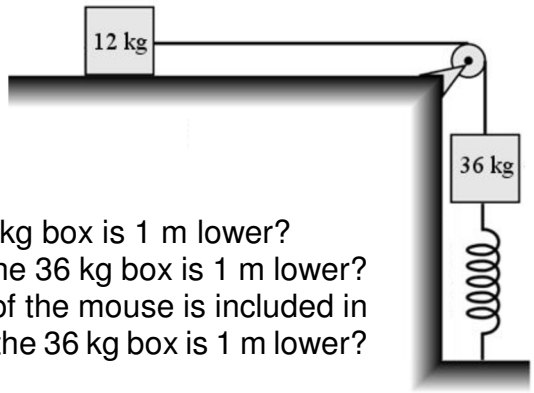


a) What is the angular acceleration of the cylinder?
b) What is the final angular speed?
c) What is the mass of the cylinder?
d) What is the final kinetic energy?
e) What is the work done by the forces?

Answers: a) 2.5π rad/s² b) 10π rad/s c) 42.44 kg d) 942.5 J (300π J)
e) 942.5 J (300π J)

19. (12 points)

In the situation shown in the diagram, the two boxes are initially at rest. The spring constant is 600 N/m and the spring is initially stretched 2 m. Then, the boxes start to move. There is no friction.

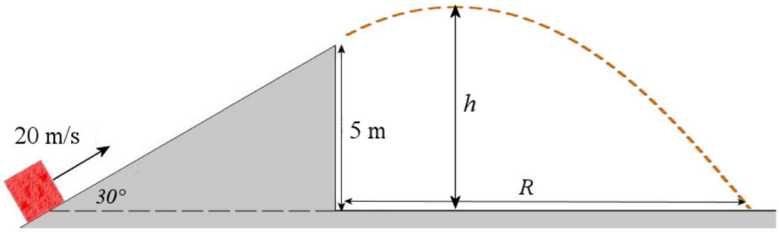


a) What will the speed of the boxes be when the 36 kg box is 1 m lower?
b) What will the acceleration of the boxes be when the 36 kg box is 1 m lower?
c) If there was a mouse in the 12 kg box (the mass of the mouse is included in the 12 kg), how many g would it experience when the 36 kg box is 1 m lower?

Answers: a) 7.225 m/s b) 19.85 m/s² c) 2.259

20. (12 points)

A block is moving uphill of a ramp, as shown in the diagram. There is no friction.

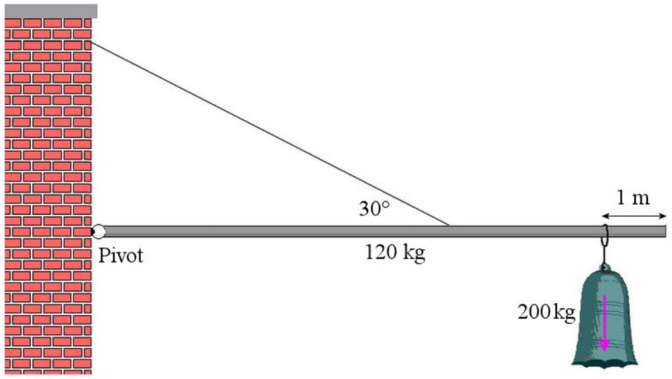


a) How far away from the ramp will the block fall (R in the diagram)?
b) What is the maximum height reached by the block (h in the diagram)?
c) What is the speed of the block at the highest point?
d) What is the speed of the block just before hitting the ground?
e) How long last this movement (from the block is at the bottom of the ramp up to the moment when it hits the ground)?

Answers: a) 33.57 m b) 8.852 m c) 15.05 m/s d) 20 m/s e) 2.766 s

21. (10 points)

In the situation shown, the beam is 10 m long and the cable is fixed 6 m from the pivot.



a) What is the tension of the cable?
b) What is the force (magnitude and direction) of the force exerted by the pivot on the beam? On the diagram, draw a vector showing the direction of this force.

Answers: a) 7840 N b) 6834.8 N at -6.59°