Technical University of Denmark

Written examination, Saturday 26 August, 2017

Course name: Physics 1

Course number: 10018

Exam duration: 4 hours

Aids allowed: All aids allowed

Weighting: The submission is judged as a whole.

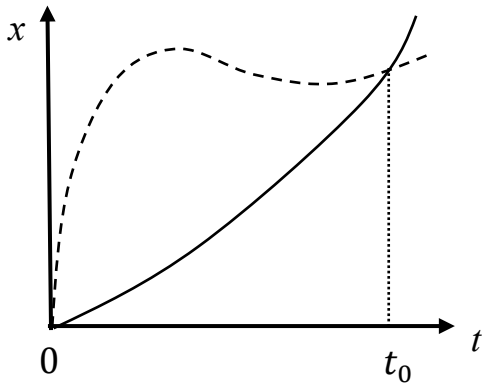
The exam consists of 15 multiple choice questions that should be answered on CampusNet. All questions *must* be answered (if a question is not answered it is assumed that the intended answer is ”Don’t know”). Wrong answers deduct in the evaluation. In some questions a single option is the correct answer, in other questions the correct answer is a combination of several options.

Question 1.

A car is traveling on a straight line. The car starts from rest and accelerates with constant acceleration a for a period of time. Next, the driver hits the brake and the car comes to a complete stop after braking. During braking, the magnitude of the constant acceleration is $2a$. The whole movement takes time T. How far has the car moved during the movement?

A) $\frac{1}{2}aT^2$
B) $\frac{1}{3}aT^2$
C) $\frac{1}{4}aT^2$
D) aT^2
E) $2aT^2$
F) $3aT^2$
G) $4aT^2$
H) Don't know

Questions 2.



Two particles start in the same position at the same time and move along a straight line. The figure shows the position of the two particles as a function of time.

Which of the following statement(s) is/are correct?

At time t_0:

A) Both particles have the same speed.
B) Both particles have the same velocity.
C) Both particles have the same position.
D) Both particles have traveled the same distance in the period from 0 to t_0.
E) Both particles have the same average velocity in the period from 0 to t_0.
F) Don't know

Question 3.

A small projectile with a mass *m* is dropped from a plane flying at a horizontal velocity *v*. When the projectile is dropped, the plane is at the height *h* above the ground. Ignore the air resistance.

The horizontal distance *L* from the point on the ground over which the projectile is dropped to the point where the projectile hits the ground is given by

A) $L = \frac{1}{2}gt^2$

B) $L = v\left(\frac{2h}{g}\right)^2$

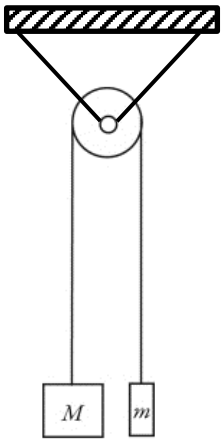
C) $L = 2mv\sqrt{\frac{2h}{g}}$

D) $L = v\sqrt{\frac{2h}{g}}$

E) Don't know

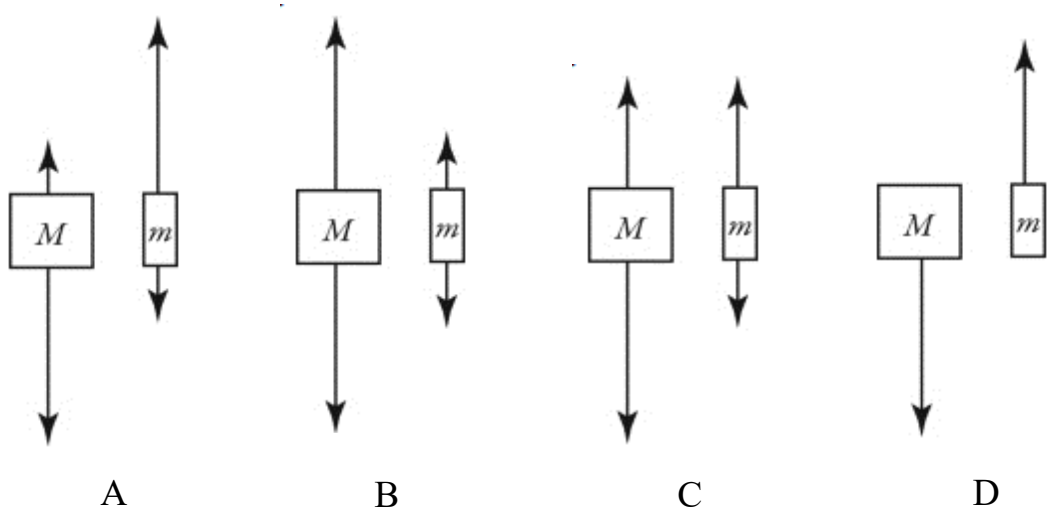
Question 4.

Two loads of different masses ($M > m$) are connected with a string that runs over a frictionless, massless pulley. When the system is released, the loads will begin to accelerate. The system is shown in the figure to the right.



Below are four different pairs of free-body diagrams for the two loads.

Which pair of free-body diagrams best corresponds to the situation relating to the movement of the loads?

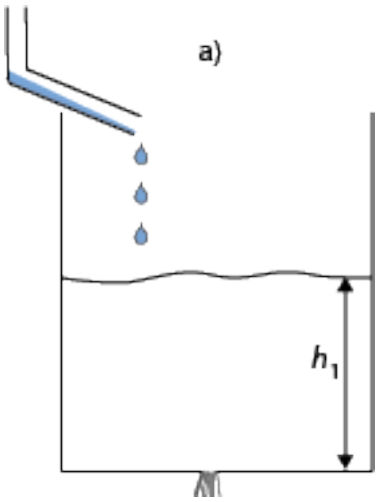


A B C D

A) A
B) B
C) C
D) D
E) Don't know

Question 5.

A water barrel is filled with water from a drain pipe with a constant liquid flow rate of $3.2 \cdot 10^{-4}\ \mathrm{m}^3/\mathrm{s}$. However, a small circular hole has been created at the bottom of the container with a radius of 0.50 cm, where the water flows out again, as shown in a). The water barrel has a diameter that is much larger than the hole, so you can assume the velocity at the surface of the water to be 0.0 m / s. How high will the water level be at equilibrium?



A) $h_1 = 0.84$ m
B) $h_1 = 1.1$ m
C) $h_1 = 0.21$ m
D) $h_1 = 0.0$ m
E) Don't know

Question 6.

A small pearl with a mass *m* can slide around the bottom of a container with a horizontal, smooth bottom. The bottom of the container is circular with radius *R*. The container's sides lean outwards, as seen at the left below. The situation from the side is shown below to the right. The pearl is pushed and it moves around in a horizontal, uniform circular motion. As the pearl is in contact with the bottom, it is influenced by a normal force n_1 and as it is in contact with the side of the container, it is influenced by a normal force n_2.

It is assumed that the pearl moves around the container with a speed *v*.

Which of the following equation(s) is/are correct?

A) $n_1 = mg$
B) $n_2 = m\frac{v^2}{R}$
C) $n_1 + n_2 \sin\theta = mg$
D) $n_1 + n_2 \cos\theta = mg$
E) $n_2 + n_1 \sin\theta = m\frac{v^2}{R}$
F) $n_2 + n_1 \cos\theta = m\frac{v^2}{R}$
G) $n_2 \cos\theta = m\frac{v^2}{R}$
H) $n_2 \sin\theta = m\frac{v^2}{R}$
I) Don't know

Question 7.

We consider two physical situations. In the first situation, we have a person starting from rest and then starts to run horizontally on the ground. In the second situation, we have a person starting from rest and then starts to swim in the water. The person who runs is in contact with the ground and the swimmer is in contact with the water.

Which of the following statement(s) is/are correct?

A) The runner and the ground receive the same magnitude momentum from their interaction.
B) The runner receives a greater amount of momentum than the ground from their interaction.
C) The ground receives a greater amount of momentum than the runner from their interaction.
D) The swimmer and the water receive the same magnitude momentum from their interaction.
E) The swimmer receives a greater amount of momentum than the water from their interaction.
F) The water receives a greater amount of momentum than the swimmer from their interaction.
G) The runner and the ground receive equal amounts of kinetic energy from their interaction.
H) The runner receives more kinetic energy than the ground from their interaction.
I) The ground receives more kinetic energy than the runner from their interaction.
J) The swimmer and the water receive equal amounts of kinetic energy from their interaction.
K) The swimmer receives more kinetic energy than the water from their interaction.
L) The water receives more kinetic energy than the swimmer from their interaction.
M) Don’t know

Question 8.

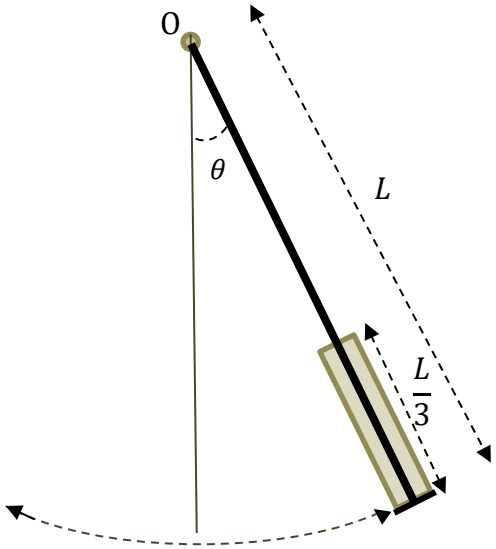
Two blocks A and B move on a smooth table along a straight line towards each other. The blocks have the same speed u. Block A has a mass m and moves to the right (positive direction), while block B has the mass $4m$ and moves to the left. On the front of each block is a spring that ensures that the blocks collide elastically.

The velocities of the blocks v_A and v_B after the impact is:

A) $v_A = -\frac{11}{5}u$ and $v_B = -\frac{1}{5}u$
B) $v_A = 0$ and $v_B = 0$
C) $v_A = -\frac{23}{17}u$ and $v_A = -\frac{7}{17}u$
D) $v_A = -u$ and $v_B = u$
E) Don't know

Question 9.

In a simple model of a child on a swing, the swing consists of two parallel bars of length L. The swing rotates smoothly about an axis O through the ends of the rods. The child is sitting on a seat, whose mass can be ignored, and one can also ignore the masses of the rods. The child has a mass M, and can be considered a homogeneous rod of length $L/3$, located parallel to the rods of the swing and with one end of the seat (see figure). The moment of inertia of the rod (child) with respect to the axis of rotation is $I_0 = \frac{19}{27}ML^2$.
The swing with the child is pulled away from the equilibrium position and released. As the swing is released, the center of gravity is at a location that is h higher than the center of gravity would be when the swing is at its lowest point.

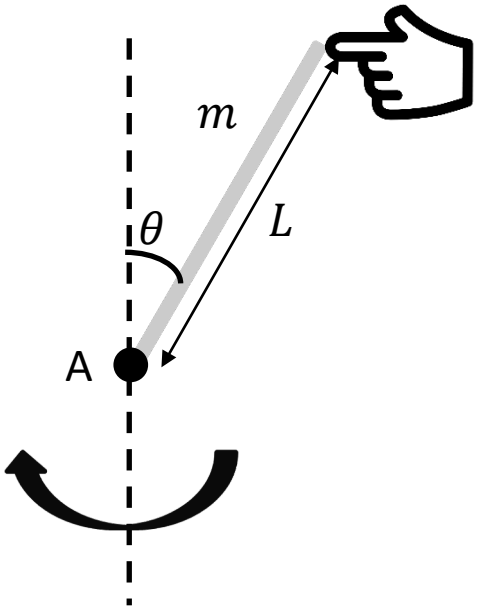


What is the force on the bearing in point O when the swing with the child passes its lowest position?

A) $Mg\left(1+\frac{12h}{5L}\right)$
B) $Mg\left(1+\frac{2gh}{L}\right)$
C) Mg
D) $Mg\left(1+\frac{45}{19}\frac{h}{L}\right)$
E) Don't know

Question 10.

A thin homogeneous stick with a mass m and the length L is attached onto a frictionless bearing at point A. The stick is supported by a finger. The finger acts with a constant horizontal force $\vec{F}$ on the stick, which forms an angle θ with the vertical. See the figure.

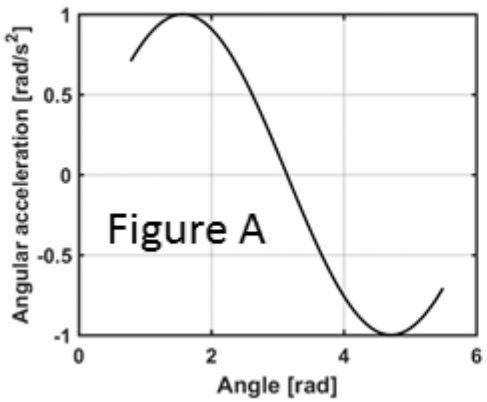


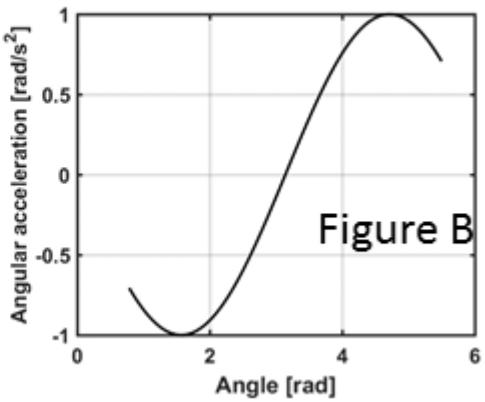
What is the magnitude of the force, F?

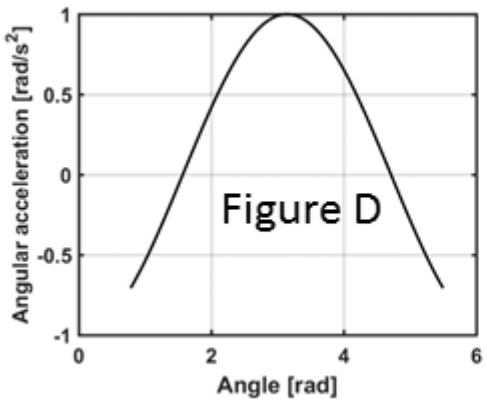
A) $\frac{1}{2}mg$
B) $mg\tan\theta$
C) mg
D) $\frac{1}{2}mg\tan\theta$
E) Don't know

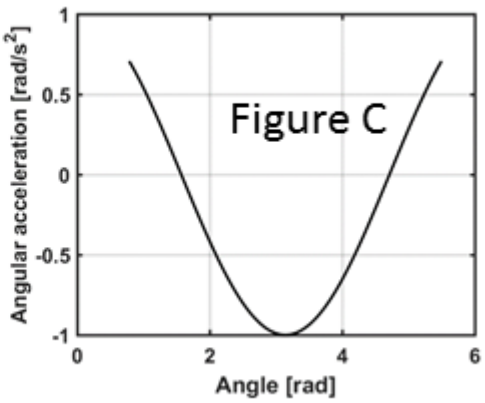
Question 11. [Continuation of previous question]

The finger is now removed and the stick starts to swing. Which of the figures indicates the correct path of angular acceleration of the stick as a function of angle?





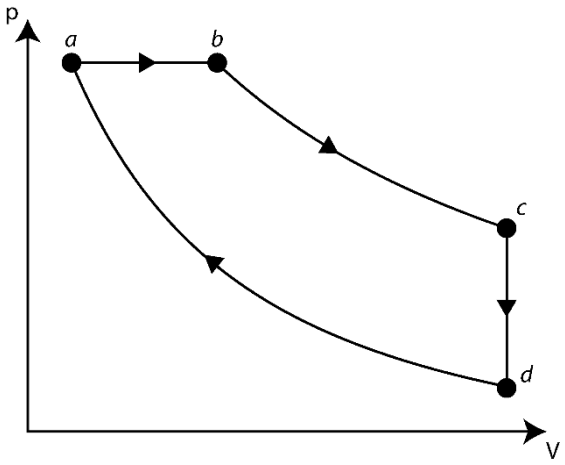




A) Figure A
B) Figure B
C) Figure C
D) Figure D
E) None of these
F) Don’t know

Question 12.

The pV-diagram shows a cyclic process for a monoatomic ideal gas. The process consists of four sub-processes that take place in the order indicated in the figure, starting at state a. It is stated that the following applies to the temperature: $T_b = T_c$ and $T_d \neq T_a$. No heat is exchanged with the environment in the process $d \rightarrow a$.



What is the correct order of the processes?

A) Isobaric, isothermal, isochoric, adiabatic
B) Isobaric, isothermal, isochoric, isothermal
C) Isochoric, isothermal, isobaric, adiabatic
D) Isobaric, adiabatic, isochoric, isothermal
E) Don't know

Question 13. [Continuation of previous question]

The ideal gas contains 1.50 mol. If the temperature in state *b* is 120 ° C and the gas in state *c* has a volume of 2.50 L, what is then the pressure in state *c*?

A) $1.96 \cdot 10^6$ Pa
B) $0.599 \cdot 10^6$ Pa
C) 1960 Pa
D) 598 Pa
E) Don't know

Question 14. [Continuation of previous question]

What process(es) add heat to the system?

A) $a \rightarrow b$
B) $b \rightarrow c$
C) $c \rightarrow d$
D) $d \rightarrow a$
E) Don't know

Question 15. [Continuation of previous question]

The volume in state *a* is 1.0 L, and in state *b* it is 1.5 L. The cyclic process shown in the pV-diagram operates between a minimum and a maximum temperature. How effective could an optimal theoretical process be between these two temperatures?

A) 0.33
B) 0.46
C) 0.72
D) 0.64
E) Don't know