Technical University of Denmark

Page 1 of 12 pages

Written examination, Saturday, May 25, 2019

Course name Physics 1

Course No. 10018

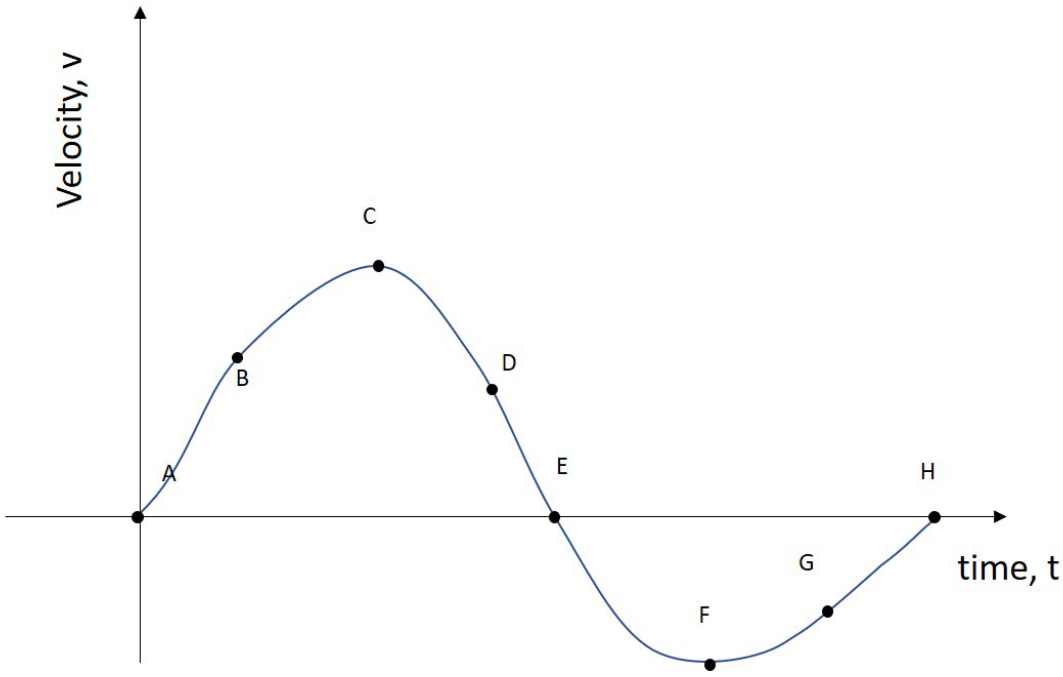
Duration: 4 hours

Permitted aids: All aids allowed

"Weighting": The test is judged as a whole.

The set consists of 19 multiple choice questions that are answered in the task module at DTU Inside. All questions must be answered (if a question by mistake is not answered, it is assumed that the chosen answer is "Do not know"). Wrong answers will have a negative impact in the assessment. In some questions, only one of the options is the right answer, in other questions the right answer is given by a combination of several answers.

Question 1.
A researcher is studying wild wolves in Jutland. A particular wolf has been captured and equipped with a GPS transmitter so that the researcher can follow the wolf's movement. The graph below shows the speed of the wolf as a function of time while moving on a straightforward forest path.



In which of the marked points (A-H) does the wolf not move?
A) Only E
B) A, E and H
C) C and F
D) None of the points. The wolf moves all the time.
E) Do not know

Question 2. [Continuation of previous questions]

In which of the marked points (A-H) does the wolf not accelerate?

A) Only E
B) A, E and H
C) C and F
D) At all points, the wolf never accelerates
E) Do not know

Question 3. [Continuation of previous questions]

In what interval(s) does the wolf move at approximately constant acceleration?
A) A-B
B) B-C
C) D-E and G-H
D) C-D and E-F
E) B-C and F-G
F) Do not know

Question 4. [Continuation of previous questions]

At what time is the wolf furthest from its starting position at $t = 0$?
A) C
B) E
C) F
D) H
E) Do not know

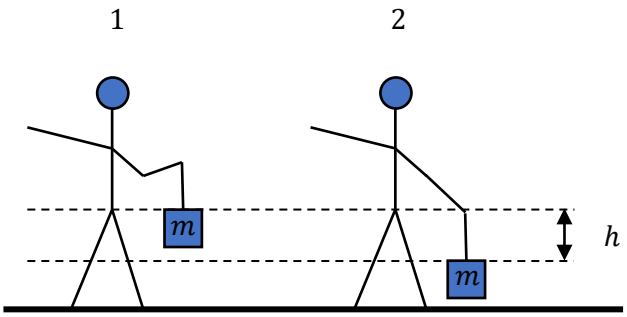
Question 5.

A pirate ship shoots off a cannonball. The ball mass is 15 kg and the firing itself lasts 50 ms from the time the gunpowder explodes until the cannonball has left the mouth of the cannon. The effect of the explosion on the ball can be described by a force which is on average 60 kN while the ball is in the gun barrel. The gun is aligned to be horizontal during firing and is 5.0 meters above sea level. Disregard effects due to air resistance. Which of the distances below is closest to how far the cannonball flies before it hits the water surface?

A) 200 m
B) 1000 m
C) 500 m
D) 100 m
E) 50 m
F) 1500 m
G) Do not know

Question 6.

A person holds a box at rest with a cord (starting situation, figure 1). The box has the mass m. The person now lowers the box vertically downwards so that it has constant acceleration, $a = \frac{g}{4}$. In total, the box height is lowered h (the final situation is figure 2). Note that in situation at figure 2, the speed of the box is not zero.



What is the magnitude of the string tension on the cord, *S*, under the movement from 1 to 2?

A) $S = mg$

B) $S = \frac{1}{3}mg$

C) $S = \frac{2}{3}mg$

D) $S = \frac{1}{4}mg$

E) $S = \frac{1}{2}mg$

F) $S = \frac{3}{4}mg$

G) Do not know

Question 7. [Continuation of previous question]

How much work, *W*, did the person do on the box during the move from 1 to 2?

A) $W = \frac{1}{4}mgh$
B) $W = -\frac{1}{4}mgh$
C) $W = \frac{3}{4}mgh$
D) $W = -\frac{3}{4}mgh$
E) $W = \frac{4}{3}mgh$
F) $W = -\frac{4}{3}mgh$
G) Do not know

Question 8.

A rocket starts by having a mass of 10000 kg. When the rocket starts to go vertically upwards, it uses fuel at a rate of 100 kg/s. The fuel is sent out at a speed of 2000 m/s, compared to the rocket. Gravity is taken into account, but not air resistance.

What is the rocket's acceleration after 20 s?

A) 2.3 m/s^2
B) 13 m/s^2
C) 15 m/s^2
D) 23 m/s^2
E) 58 m/s^2
F) 10 m/s^2
G) Do not know

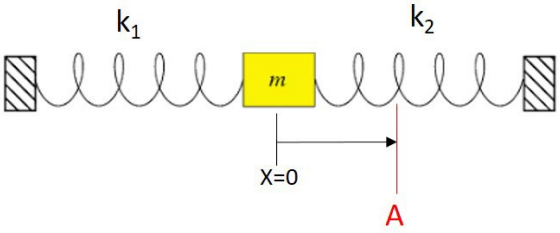
Question 9.

You have a 2.0 m long pendulum with a 100 kg ball attached to it. The ball is then swung upwards until it is 1.0 m higher than its lowest position. The ball is let go and as it swings back and forth a 50 kg child jumps on the ball when the ball is at its lowest position. After the child jumps on the ball, what is the pendulum's change in angle from vertical at the maximum height?

A) There is no change in the angle with the vertical in the top position
B) 10°
C) 12°
D) 15°
E) 19°
F) 21°
G) 27°
H) Do not know

Question 10.

The figure below shows a mass between 2 springs of varying spring constants. Each spring is attached to a non-movable wall. The displacement is $x = 0$ when the springs are in equilibrium. The mass is given the displacement $x = A$, and released. What is the velocity as a function of these parameters as well as displacement x?



A) $v = \frac{1}{2m}(k_1 + k_2)(A^2 - x^2)$
B) $v = \frac{(k_1+k_2)x^2}{2mA^2}$
C) $v = \sqrt{\frac{k_1+k_2}{m}(A^2 - x^2)}$
D) $v = \sqrt{\frac{k_1+k_2}{m(A^2-x^2)}}$
E) $v = \sqrt{\frac{k_1+k_2}{m}(A^2 + x^2)}$
F) $v = \sqrt{\frac{1}{2m}(k_1 + k_2)(A^2 - x^2)}$
G) Do not know

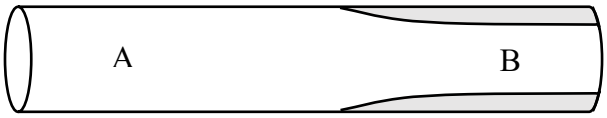
Question 11.

A ball with a mass *m* is suspended by a massless and inextensible string with a length *l*. Initially, the ball is at rest. This ball is then hit (directly in the middle of the ball) by a second identical ball, which moves horizontally at constant speed. The two balls undergo an elastic collision. What should the minimum speed of the incoming ball be to at least allow the suspended ball to perform a vertical circular motion?

A) $\sqrt{lg}$
B) $\sqrt{2lg}$
C) $\sqrt{2.5lg}$
D) $\sqrt{5lg}$
E) $\frac{5}{4}lg$
F) $2\sqrt{lg}$
G) $\sqrt{3lg}$
H) Do not know

Question 12.

A cylindrical water pipe has an inner radius *R* at point A. At point A, the water pressure is p_A and the water flows laminarly without friction at the speed v_A. The water in the pipe has a density of ρ. Further, down on the pipe, at point B, there has been a calcification (i.e. dirt build-up) of the pipe and the inner radius of the pipe is only 3*R*/4.

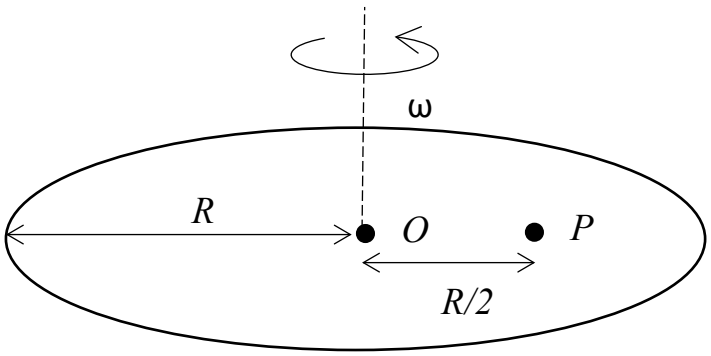


What is the water pressure p_B and the water flow rate, v_B, at B?

A) $p_B = p_A - \frac{175}{162}\rho {v_A}^2$, $v_B = \frac{16}{9}v_A$
B) $p_B = p_A - \frac{175}{81}\rho {v_A}^2$, $v_B = \frac{16}{9}v_A$
C) $p_B = p_A - \frac{7}{18}\rho {v_A}^2$, $v_B = 16v_A$
D) $p_B = p_A - \frac{15}{2}\rho {v_A}^2$, $v_B = 4v_A$
E) $p_B = p_A - \frac{255}{2}\rho {v_A}^2$, $v_B = 16v_A$
F) $p_B = p_A - \frac{7}{18}\rho {v_A}^2$, $v_B = \frac{16}{9}v_A$
G) $p_B = p_A - \frac{7}{18}\rho {v_A}^2$, $v_B = \frac{4}{3}v_A$
H) Do not know

Question 13.

A homogeneous cylindrical disc with the mass *M* and radius *R* rotates at the angular velocity ω around the center of mass of the disk *O*, as shown in the figure. A small coin with the mass *m* lies at point *P* at the distance $r = R/2$ from *O*. At low angular speeds, the coin is fixed on the disc and rotates around with the disc due to static friction. The gravitational acceleration is *g* and the static coefficient of friction is μ_s.



At what angular velocity does the coin slide out from the disc?

A) $\omega = \sqrt{2\mu_s g/R}$
B) $\omega = \sqrt{2\mu_s mg/MR}$
C) $\omega = \sqrt{\mu_s g/R}$
D) $\omega = \sqrt{\mu_s gr/2R}$
E) $\omega = \sqrt{\mu_s \omega^2/2}$
F) Do not know

Question 14.

An atomic nucleus, which is initially at rest, decays by emitting an electron with a momentum of 1.19 MeV/c and an antineutrino is emitted perpendicular to the direction of the electron with a momentum of 1.00 MeV/c. [MeV/c is a unit of momentum. MeV (mega-electronvolt) is an energy unit, with 1 MeV $= 1.60 \cdot 10^{-13}$ J , and c is the speed of light]. When using the concepts of classical mechanics, which of the following angles is closest to describing the smallest angle that the atomic nucleus velocity vector (after decay) forms with the antineutrino's velocity vector?

A) 0°
B) 230°
C) 180°
D) 50°
E) 140°
F) 90°
G) 130°
H) 270°
I) Do not know

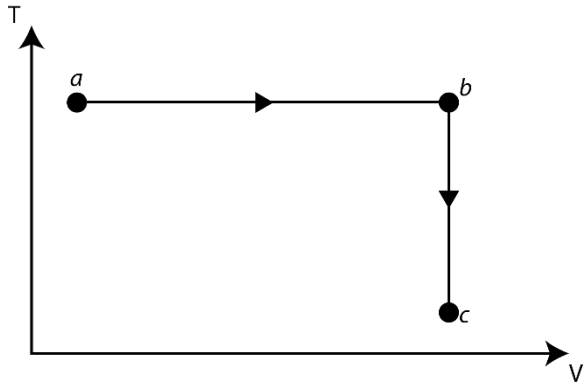
Question 15.

A grinding wheel, shaped like a solid cylinder, rotates at 180 rpm. The grinding wheel has a mass of 40 kg and a radius of 0.50 m. You put an ax on the edge of the wheel to get it sharpened. You push the ax against the wheel with a normal force of 120 N and the ax has a coefficient of friction with the grinding wheel of 0.60. How fast does the grinding wheel stop rotating?

A) 1.6 s
B) 2.6 s
C) 12 s
D) 25 s
E) Do not know

Question 16.

Consider the case of 1.00 mole of a monoatomic ideal gas starting at point *a* and moving along the indicated path in the temperature volume (*TV*) diagram to the right. The temperature at point *a* is 230 °C, while the volume is 1.20 L.



Which thermodynamic processes does the gas undergo and in which order?

A) Isobar, isochore
B) Isochore, isotherm
C) Isotherm, isochore
D) Isobar, isotherm
E) Do not know

Question 17. [Continuation of previous questions]

At point *b*, the volume is 2.30 L. What should the temperature be at point *c* before we can return the gas to point *a* with an adiabatic process?

A) 282 ° C
B) 149 °C
C) 87 ° C
D) 53 ° C
E) Do not know

Question 18. [Continuation of previous questions]

We now adjust the process so that the volume in point *b* becomes 1.80 L and the temperature at point *c* becomes 111 °C. This ensures that $c \rightarrow a$ is an adiabatic process.

How much work is done in the thermodynamic cycle $a \rightarrow b \rightarrow c \rightarrow a$?

A) -709 J
B) -1472 J
C) 356 J
D) 212 J
E) Do not know

Question 19. [Continuation of previous questions]

How much entropy is generated in the various processes during the cycle $a \rightarrow b \rightarrow c \rightarrow a$?

A) $\Delta S_{ab} = 3.4\ \mathrm{J/K},\ \Delta S_{bc} = -3.4\ \mathrm{J/K}, \Delta S_{ca} = 0\ \mathrm{J/K}$
B) $\Delta S_{ab} = 0\ \mathrm{J/K},\ \Delta S_{bc} = -3.4\ \mathrm{J/K}, \Delta S_{ca} = 0\ \mathrm{J/K}$
C) $\Delta S_{ab} = 2.2\ \mathrm{J/K},\ \Delta S_{bc} = -2.2\ \mathrm{J/K}, \Delta S_{ca} = 0\ \mathrm{J/K}$
D) $\Delta S_{ab} = 3.4\ \mathrm{J/K},\ \Delta S_{bc} = -9.1\ \mathrm{J/K}, \Delta S_{ca} = 0\ \mathrm{J/K}$
E) $\Delta S_{ab} = 0\ \mathrm{J/K},\ \Delta S_{bc} = -9.1\ \mathrm{J/K}, \Delta S_{ca} = 0\ \mathrm{J/K}$
F) Do not know