AESB1320-T
01-07-15, 9:00
TN-Tentamenzaal 4.25

The exam consists of 10 Conceptual Questions (CQs), each valid for 1 point, and 10 Exercises (EXs), each valid for 4 points. The maximum score is 50. In order to pass 29 points are required.

Important: *Answers to conceptual questions need to be accompanied by a short (1-2 sentences) motivation of the choice. Credits for a conceptual question can only be obtained when both the answer and the motivation are correct.*

Grading rules for numerical exercises:
- correct numeric value and solution: 4 points;
- wrong numeric value, but correct solution (computational mistake): 3 points;
- wrong numeric value, correct intermediate numeric value (exercise half-done): 2 points;
- wrong solution, but correct setup (including complete sketch): 1 point;
- wrong solution, wrong/missing setup: 0 points.

This is a closed-book exam: only pens, blank paper and non-graphical calculators are allowed.

CQ1
Suppose that an object is moving with constant nonzero acceleration. Which of the following is an accurate statement concerning its motion?
A. In equal times it moves equal distances.
B. A graph of its velocity as a function of time is a horizontal line.
C. In equal times its velocity changes by equal amounts.
D. In equal times its speed changes by equal amounts.
E. A graph of its position as a function of time has a constant slope

C: dv=a dt, so if dt is equal also dv is equal.

EX1
A sport car starts from rest and travels 400 meters in 6.30 s with constant acceleration.
What is its velocity when it crosses the finish line (expressed in km/h)?

458 km/h
[$x=1/2\ at^2$-> $a=20{,}16\ m/s^2$; v=at...]

CQ2
If you set the cruise control of your car to a certain speed and take a turn, the speed of the car will remain the same. Is the car accelerating?
A. No.
B. Yes.

B: The velocity vector is changing direction; hence the acceleration is different from zero (and directed perpendicularly to the direction of motion).

EX2
A small boat is moving at a velocity of 3.91 m/s when it is accelerated by a river current perpendicular to the initial direction of motion.
If the acceleration of the current is 0.75 m/s^2, what will be the new velocity of the boat after 39.1 s?

Determine both magnitude and direction of the velocity.

29.6 m/s at 82.4^o from the initial direction of motion (2 points if only velocity components are given).
[v_p=at=29,33 m/s; v=sqrt($v_0^2+v_p^2$); angle=atan(v_p/v_0)]

CQ3
A fish weighing 16 N is weighed using two spring scales, each of negligible weight, as shown in the figure. What will be the readings of the scales?

A. The bottom scale will read 16 N, and the top scale will read zero.
B. The top scale will read 16 N, and the bottom scale will read zero.
C. Each scale will read 8 N.
D. Each scale will read 16 N.
E. The scales will have different readings, but the sum of the two readings will be 16 N.

D: If the scales have no mass, they will both read the total mass of the fish.

EX3
Two forces act on a 7.0-kg object, causing it to accelerate by 1.0 m/s^2 toward the east. One of the forces is 10.0 N acting toward the east.
What are the magnitude and direction of the second force?

3.0 N west
[F_{net}=ma=7 N; $F_2=F_{net}-F_1$=7-10=-3 N]

CQ4
Three people are pushing a car up a hill at constant velocity. The net force on the car is
A. zero.
B. up the hill and greater than the weight of the car.
C. down the hill and greater than the weight of the car.
D. down the hill and equal to the weight of the car.
E. up the hill and equal to the weight of the car.

A: If the car moves with constant velocity, then the net acceleration has to be zero.

EX4
You push downward on a box at an angle 25° below the horizontal with a force of 750 N. The box is on a flat horizontal surface for which the coefficient of static friction with the box is 0.64.
What is the mass of the heaviest box you will be able to move?

76 kg
[F_y=F sin25=315 N; F_x=F cos25=679.7 N; $F_f=\mu$ n= μ (Fy+mg); $F_f=F_x$...]

CQ5
A 4.0-kg object is moving with speed 2.0 m/s. A 1.0-kg object is moving with speed 4.0 m/s. Both objects encounter the same constant braking force, and are brought to rest. Which object travels the greatest distance before stopping?
A. the 4.0-kg object

B. the 1.0-kg object
C. Both objects travel the same distance.
D. It is impossible to know without knowing how long each force acts.

C: Both objects have the same initial kinetic energy (K_initial=1/2 mv^2), hence they work done to stop them (when K_final=0) is the same. Since the work done is equal to the force times the travelled distance, and the forces are the same, also the travelled distance will be the same.

EX5
A 60.0-kg person falls from rest onto a platform supported by an ideal spring. The distance between the initial position of the person and the platform is 1.20 m. The platform drops 6.00 cm before the person comes to rest.
What is the spring constant of the spring? You can neglect the mass of both platform and spring.

4.12×10^5 N/m (2 points if 3.92×10^5 N/m)
[h=1.2 m; d=6 cm; W_g=mg(h+d)=740.9 J; W_s=1/2 $k\,x^2$ = -0.0018 k J ; W_g=-W_s...]
[If W_g=mgh, k=3.92×10^5 N/m]

CQ6
The reason an astronaut in a satellite orbiting around the earth feels weightless is that
A. the astronaut is at a point in space where the effects of the moon's gravity and the earth's gravity cancel.
B. the astronaut's acceleration is zero.
C. the astronaut is beyond the range of the earth's gravity.
D. the astronaut is in free fall.

D: The acceleration of the astronaut is equal to the acceleration of gravity, or equivalently the net force on the astronaut is equal to the force of gravity, so the astronaut will feel no force counteracting gravity (standing on earth what you feel is the force between you and the ground, which ensures that the net force is zero).

EX6
From what height above the surface of the earth should an object be dropped to initially experience an acceleration of 0.92 g? The radius of the earth is 6.38×10^6 m. Express your answer in km.

270 km
[$g=GM/R^2$, with R=6. 38 x 10^6 m; $a=GM/r^2$=0.92 g...]

CQ7
As a tile falls from the roof of a building to the ground its momentum is conserved.
A. True
B. False

B: The tile is accelerating due to gravity and its velocity is changing: the momentum is also changing. Equivalently: momentum is only conserved if the net force is zero.

EX7
A thin rod of length L has a linear density $\lambda(x)=Ax$, where x is the distance from the left end of the rod.
I. What is the mass of the rod?
II. How far is the center of mass of the rod from the left end of the rod?

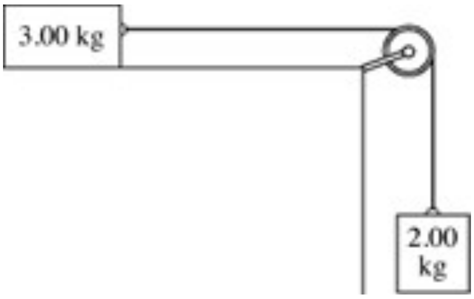
I: $AL^2/2$
II: $2L/3$
[M=integral(Ax dx); x_{CM}=integral(x Ax dx)/M; with integrals evaluated between 0 and L]

CQ8
When a rigid body rotates about a fixed axis, all the points in the body have the same

A. tangential speed.
B. linear displacement.
C. angular acceleration.
D. tangential acceleration.
E. centripetal acceleration.

C: All other quantities depend on the distance from the rotation axis.

EX8
Two blocks are connected by a weightless string that passes over a frictionless pulley (see figure). The masses of the two blocks are 2.00 kg (lower block) and 3.00 kg (upper block). The pulley has a moment of inertia equal to 0.004 kg m^2 and a radius equal to 5.0 cm. The coefficient of friction of the tabletop is 0.3. The blocks are released from rest.
Find the speed of the upper block when it has moved by 0.6 m.



1.4 m/s
[m_1=2 kg; m_2=3 kg; d=0.6 m; I=0.004 kg m^2; R=5 cm; μ =0.3;
$W_g=m_2\, g\, d$=11.76 J; $W_f= \mu\, m_1\, g\, d$ = 5,29 J; $\Delta W=W_g-W_f=K_1 + K_2 + K_p = \frac{1}{2} v^2 (m_1 + m_2 + I/R^2)=3.3\, v^2$...]

CQ9
The angular momentum of a system remains constant

A. when no torque acts on the system.
B. all the time since it is a conserved quantity.
C. when no net external force acts on the system.
D. when the total kinetic energy is constant.
E. when the linear momentum and the energy are constant.

A: You need a torque to change the angular velocity, hence the angular momentum.

EX9
A potter's wheel, with rotational inertia 0.6 kg m^2, is spinning freely at 4.2 rad/s. The potter drops a lump of clay onto the wheel, where it sticks a distance 0.2 m from the rotational axis. If the subsequent angular speed of the wheel and clay is 3.9 rad/s what is the mass of the clay? You can consider the lump of clay as a point mass.

1.15 kg
[$L_i=I\,\omega_i$=2.52 kg m^2/s; $L_f=(I+ m\, 0.2^2)\,\omega_f$...]

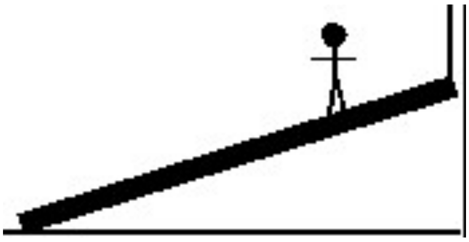
CQ10
A boy and a girl are balanced on a seesaw (in Dutch: wip). If they both move forward so that they are one-half their original distance from the pivot point, what will happen to the seesaw? Assume that both people are small enough compared to the length of the seesaw to be thought of as point masses, and that you can neglect the mass of the seesaw.

A. It is impossible to say without knowing the masses.
B. Nothing will happen; the seesaw will still be balanced.

C. The side the boy is sitting on will tilt downward.
D. The side the girl is sitting on will tilt downward.
E. It is impossible to say without knowing the distances.

B: To maintain balance, the net torque has to remain equal to zero. The individual torques are equal to the cross-product of the force (weight) and distance from the pivot. Since the weights remain the same, and both distances change by 50%, the individual torques will remain equal to each other in magnitude (and opposite in direction).

EX10
A 20.0-kg uniform plank is supported by the floor at one end and by a vertical rope at the other end see figure). A 50.0-kg mass person stands on the plank at a distance of three-fourths of the length of the plank (measured from the end at the side of the floor).



I. What is the tension of the rope?
II. What is the magnitude of the force that the floor exerts on the plank?

I: 466 N
II: 220 N
[M=20 kg; m=50 kg;
Torque balance: $L/2 \cos\theta\, Mg + \frac{3}{4} L \cos\theta\, mg - L \cos\theta\, T = 0$ -> T=466 N;
Vertical forces balance: $F_{floor}=(M+m)g - T=220$ N]