Solutions of the Mock Exam

Fall Semester 2017

1 Velocity (5 Points)

(a) The total path of the car is composed of two sections:

1. the path which the car drives during the reaction time
2. the path during breaking

Path 1 is a uniform motion:

$$v = \frac{s}{t} \quad \textbf{(1 point)}$$
$$\Rightarrow v = vt_r = 30\text{m/s} \cdot 0.8\,\text{s}$$
$$s = 24\,\text{m} \quad \textbf{(1 point)}$$

(total 2 Points)

(b) Path 2 is a uniform accelerated motion:

$$s = \frac{a}{2}t^2 \quad \textbf{(1 point)}$$

The time till the car is standing still is:

$$t = \frac{v}{a}$$

put in the formula for s:

$$s = \frac{v^2}{2a} \quad \textbf{(1 point)}$$
$$= 72.6\,\text{m} \quad \textbf{(1 point)}$$

From this it follows that the total stopping distance is 96.6 m. Since the distance to the truck was just 90 m, the car does not manage to stop before reaching the truck.

(total 3 Points)

2 Acoustic wave (10 Points)

(a) Frequency $f = \frac{\omega}{2\pi} = \frac{1980\text{s}^{-1}}{2\pi} = 315.1\,\text{Hz}$ **(2 Points)**

(b) The wavelength can be calculated from the wave number $k = \frac{2\pi}{\lambda} = 6\mathrm{m}^{-1}$
$\Rightarrow \lambda = \frac{2\pi}{k} = 1.05\,\mathrm{m}$ **(2 Points)**

(c) The phase velocity is $c = \frac{\omega}{k} = \lambda f = 330\,\mathrm{ms}^{-1}$ **(2 Points)**

(d) For a harmonic wave the observed position x is irrelevant. Simplifying and setting $x = 0$:

$$y(t) = 5 \cdot 10^{-5}\,\mathrm{m} \cdot \sin(1980\,\mathrm{s}^{-1} \cdot t)$$
$$v(t) = \dot{y}(t) = 5 \cdot 10^{-5}\,\mathrm{m} \cdot 1980\,\mathrm{s}^{-1} \cos(1980\,\mathrm{s}^{-1} \cdot t)$$

(2 Points)

(e) The maximum value of the velocity is the prefactor of $v(t)$, since $|\cos_{max}| = 1$, thus $|v_{max}| = 5 \cdot 10^{-5}\mathrm{m} \cdot 1980\mathrm{s}^{-1} = 0,099\,\mathrm{ms}^{-1}$ **(2 Points)**

3 Mixed (8 Points)

(a) **(i)** Since the density of fresh water is smaller it must be true that $d_{SW} > d_{MW}$ **(1 Point)**

(ii) The ship with the cross-section area A enters d_{MW} in the seawater. The mass of the ship is:

$$m = \rho_{MW} \cdot A \cdot d_{MW} \quad \textbf{(1 Punkt)}$$

with ρ_{MW} the density of seawater. After unloading, the ship enters as deep in fresh water as before(with the load) in seawater. It has now the following mass:

$$m - \Delta m = \rho_{SW} \cdot A \cdot d_{MW} \quad \textbf{(1 Punkt)}$$

From the first equation it follows

$$A \cdot d_{MW} = m/\rho_{MW}$$

and insert into the second equation

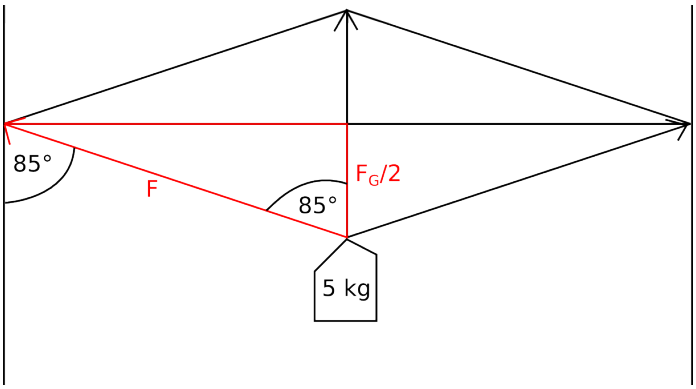
$$m = \Delta m/(1 - \rho_{SW}/\rho_{MW}) \quad \textbf{(1 Punkt)}$$
$$= 2.06 \cdot 10^7\ kg \quad \textbf{(1 Punkt)}$$

(total 4 Points)

(a) The gravitational force is:

$$F_G = mg = 49.05\,\mathrm{N} \quad \textbf{(1 Punkt)}$$

The adjacent side of the red triangle in the figure corresponds to half of the gravitational force. From this it follows:



$$\begin{aligned} \cos 85^\circ &= \frac{\frac{F_G}{2}}{F} \\ \Rightarrow F &= \frac{\frac{F_G}{2}}{\cos 85^\circ} \quad \textbf{(1 Punkt)} \\ &= 281.4\,\mathrm{N} \quad \textbf{(1 Point)} \end{aligned}$$

(total 3 Points)

4 Temperature (3 Points)

If the body K sinks by $h = 9.0\,\mathrm{mm}$, then the prolongation of the lines is

$$\Delta l = 2h = 18\,\mathrm{mm} \quad \textbf{(1 Point)}$$

The prolongation is described by

$$\begin{aligned} \Delta l &= \alpha l_0 \Delta T \quad \textbf{(1 Point)} \\ \Rightarrow \Delta T &= \frac{\Delta l}{\alpha l_0} \\ \Rightarrow \Delta T &= 50^\circ\mathrm{C} \quad \textbf{(1 Point)} \end{aligned}$$

The lines warmed up by 50°C.

(total 3 Points)

total overall 26 Points

Information to the correction

In general we give half and full points, but no quarter points. Normally you can obtain 2 points per subtask. For the right ansatz/ correct formula you get 1 point. For partially missing or faulty answers we make the following subtraction of points: minus 0.5 points for the wrong numerical value and minus 0.5 points for the wrong unit. If no formula is given, but the numerical value and the units are correct, then we subtract 1 point for the missing formula. If no formula is given, the numerical value is wrong or not given and only the units are right, you do not obtain any points for that. From this it follows:

- right ansatz/right formula solved for the wanted variable = 1 point. Example: momentum p wanted, $p = mv$
- formula correct, but wrong/no units with the correct results = 1.5 Points. Example: momentum p wanted, $m = 1\,\mathrm{kg}$, $v = 10\,\frac{\mathrm{m}}{\mathrm{s}}$, $p = mv = 10$
- Result and unit correct, but no formula given = 1 point.
  Example: momentum p wanted, $p = 10\,\frac{\mathrm{kg\ m}}{\mathrm{s}}$
- Formula and units correct, but result wrong = 1.5 points.
  Example: momentum p wanted, $m = 1\,\mathrm{kg}$, $v = 10\,\frac{\mathrm{m}}{\mathrm{s}}$ $p = mv = 7\,\frac{\mathrm{kg\ m}}{\mathrm{s}}$ (result wrong)
- Only units given = 0 points.
  Example: momentum p wanted, $[p] = \frac{\mathrm{kg\ m}}{\mathrm{s}}$
- For subsequent errors: for the first error subtraction of points as described, for all following partial results, for which the wrong first result, but correct formula was used and the result is 'correct' (considering the wrong value) you obtain the entire points.
  Example: subtask (a) wanted frequency f, $T = 2\,\mathrm{s}$, $f = \frac{1}{T} = 7\,\mathrm{Hz}$ (Result wrong) 1.5 points
  subtask (b) wanted wavelength λ, $\lambda = \frac{c}{f} = \frac{3{\cdot}10^{-8}\,\mathrm{m/s}}{7\,\mathrm{Hz}} = 4,2 \cdot 10^{7}\,\mathrm{m}$ (result with $f = 7\,\mathrm{Hz}$ correct) 2 points

For difficult calculations you get points for intermediate steps or partial results. For itemization you get 0.5 points for each answer part.