

**Total 41 marks.** Each marking point ends with ✓ and is worth one mark. Words in « » are not needed for the mark. A correct numerical answer with no working is awarded full marks unless the Notes say otherwise. ECF = error carried forward: award the mark if the candidate used their own wrong earlier answer correctly. Do not penalize errors in units or significant figures unless the Notes say so.

### Question 1: Measuring the viscosity of oil

| Part | Answers                                                                                                                         | Notes                                                                                                | Total |
|------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|-------|
| 1(a) | weight downwards AND buoyancy «upthrust» upwards AND drag upwards ✓                                                             | Award [1 max] if any extra force is shown, e.g. a "force of motion".                                 | 2     |
|      | arrow lengths consistent with equilibrium: weight = buoyancy + drag «the two upward arrows together equal the downward arrow» ✓ |                                                                                                      |       |
| 1(b) | $W = \rho Vg = 7800 \times \frac{4}{3} \pi (2.00 \times 10^{-3})^3 \times 9.8 \approx 2.56 \times 10^{-3} \text{ N}$ ✓          | A clear substitution is needed; the answer is given.                                                 | 1     |
| 1(c) | $F_b = 880 \times 3.35 \times 10^{-8} \times 9.8 = 2.9 \times 10^{-4} \text{ «N»}$ ✓                                            |                                                                                                      | 1     |
| 1(d) | $v = 0.300/10.7 = 0.028 \text{ «m s}^{-1}\text{»}$ ✓                                                                            | Allow ECF from (b) and (c). Award [2 max] if the buoyancy is left out ( $\eta = 2.4 \text{ Pa s}$ ). | 3     |
|      | $6\pi\eta rv = W - F_b \approx 2.27 \times 10^{-3} \text{ N}$ ✓                                                                 |                                                                                                      |       |
|      | $\eta = 2.27 \times 10^{-3} / (6\pi \times 2.00 \times 10^{-3} \times 0.028) = 2.2 \text{ «Pa s»}$ ✓                            |                                                                                                      |       |
| 1(e) | the acceleration decreases «from a value less than g» to zero ✓                                                                 |                                                                                                      | 1     |
| 1(f) | the sphere needs time / distance to reach terminal speed ✓                                                                      |                                                                                                      | 2     |
|      | between P and Q the speed is constant, so $v = \text{distance/time}$ is the terminal speed «needed in Stokes' law» ✓            |                                                                                                      |       |
| 1(g) | the viscosity of the oil decreases ✓                                                                                            |                                                                                                      | 2     |
|      | so the drag is smaller at a given speed and the terminal speed is larger « $v_t \propto 1/\eta$ », so the time decreases ✓      |                                                                                                      |       |

### Question 2: A block pulled by a hanging mass

| Part | Answers                                                                                                                | Notes                                                                               | Total |
|------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------|
| 2(a) | the net force on the system is the weight of the hanging mass: $0.60 \times 9.8 \llcorner = 5.9 \text{ N} \llcorner$ ✓ |                                                                                     | 2     |
|      | $a = 5.88 / (2.4 + 0.60) \llcorner = 1.96 \text{ m s}^{-2} \llcorner$ ✓                                                |                                                                                     |       |
| 2(b) | $T = 2.4 \times 1.96 = 4.7 \llcorner \text{N} \llcorner$ ✓                                                             | Allow $T = 0.60 \times (9.8 - 1.96) = 4.7 \text{ N}$ .                              | 1     |
| 2(c) | the hanging mass accelerates downwards ✓                                                                               |                                                                                     | 2     |
|      | so the net force on it is downwards: $mg - T = ma \llcorner > 0 \llcorner$ , so $T < mg$ ✓                             |                                                                                     |       |
| 2(d) | maximum static friction = $0.30 \times 2.4 \times 9.8 = 7.1 \llcorner \text{N} \llcorner$ ✓                            |                                                                                     | 2     |
|      | this is greater than the pull of $5.9 \text{ N}$ «the weight of the hanging mass», so the block stays at rest ✓        |                                                                                     |       |
| 2(e) | friction = $0.25 \times 2.4 \times 9.8 = 5.9 \llcorner \text{N} \llcorner$ ✓                                           | Award [2 max] for dividing by $2.4 \text{ kg}$ only ( $a = 2.5 \text{ m s}^{-2}$ ). | 3     |
|      | net force = $1.2 \times 9.8 - 5.9 = 5.9 \llcorner \text{N} \llcorner$ ✓                                                |                                                                                     |       |
|      | $a = 5.88 / 3.6 = 1.6 \llcorner \text{m s}^{-2} \llcorner$ ✓                                                           |                                                                                     |       |

### Question 3: A box on a truck

| Part | Answers                                                                                                                | Notes                                               | Total |
|------|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-------|
| 3(a) | static friction «from the truck on the box» ✓                                                                          |                                                     | 2     |
|      | forwards «in the direction of the acceleration» ✓                                                                      |                                                     |       |
| 3(b) | maximum friction = $0.40 \times 30 \times 9.8 = 118 \llcorner \text{N} \llcorner$ ✓                                    | Allow $a = \mu_s g = 3.9 \text{ m s}^{-2}$ for [2]. | 2     |
|      | $a = 118 / 30 = 3.9 \llcorner \text{m s}^{-2} \llcorner$ ✓                                                             |                                                     |       |
| 3(c) | it acts on the truck «not on the box» ✓                                                                                |                                                     | 2     |
|      | it acts backwards «opposite direction» / it is also a frictional «contact» force ✓                                     |                                                     |       |
| 3(d) | deceleration = $15^2 / (2 \times 25) = 4.5 \llcorner \text{m s}^{-2} \llcorner$ ✓                                      |                                                     | 2     |
|      | $4.5 \text{ m s}^{-2} > 3.9 \text{ m s}^{-2}$ , so friction cannot give the box this deceleration: the box slides ✓    |                                                     |       |
| 3(e) | the box tends to keep its velocity «inertia» while the truck slows down, so it slides forwards relative to the truck ✓ |                                                     | 1     |

### Question 4: A sled on a slope

| Part | Answers | Notes | Total |
|------|---------|-------|-------|
|------|---------|-------|-------|

|             |                                                                                                                                  |                                                                             |          |
|-------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------|
| <b>4(a)</b> | weight vertically downwards AND normal force perpendicular to the slope ✓                                                        | All four forces are needed for [2]. Each correct pair of forces scores [1]. | <b>2</b> |
|             | tension up the slope AND friction down the slope ✓                                                                               |                                                                             |          |
| <b>4(b)</b> | $F_N = mg \cos 20^\circ = 15 \times 9.8 \times \cos 20^\circ \approx 138 \text{ N}$ ✓                                            |                                                                             | <b>1</b> |
| <b>4(c)</b> | $T = mg \sin 20^\circ + \mu_d F_N \approx 50.3 + 13.8$ ✓                                                                         |                                                                             | <b>2</b> |
|             | 64 «N» ✓                                                                                                                         |                                                                             |          |
| <b>4(d)</b> | $ma = mg \sin 20^\circ + \mu_d mg \cos 20^\circ$ ✓                                                                               |                                                                             | <b>2</b> |
|             | $a = 9.8(\sin 20^\circ + 0.10 \cos 20^\circ) = 4.3 \text{ m s}^{-2}$ ✓                                                           |                                                                             |          |
| <b>4(e)</b> | $s = 2.0^2 / (2 \times 4.27) = 0.47 \text{ m}$ ✓                                                                                 | Allow ECF from (d).                                                         | <b>1</b> |
| <b>4(f)</b> | compare $\tan 20^\circ = 0.36$ with $\mu_s = 0.15$ / compare $mg \sin 20^\circ = 50 \text{ N}$ with $\mu_s F_N = 21 \text{ N}$ ✓ |                                                                             | <b>2</b> |
|             | $\tan 20^\circ > \mu_s$ «the weight component is larger than the largest static friction», so the sled slides back down ✓        |                                                                             |          |

© 2026 Ahmed Gomaa · Original material. Not affiliated with or endorsed by the International Baccalaureate Organization.