IB PHYSICS

Name: ______________________

Period: ________ Date: ____________

Marks: 136

DEVIL PHYSICS

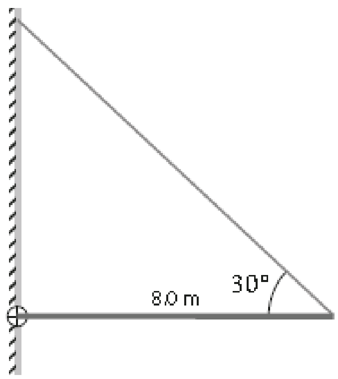
BADDEST CLASS ON CAMPUS

OPTION B TEST REVIEW
Exam-Style Questions from Textbook

Exam-style questions

Note: You may use the textbook to find any moments of inertia you may require.

1 A uniform plank of length 8.0 m and weight 1500 N is supported horizontally by a cable attached to a vertical wall. (You may use the textbook to find any moments of inertia you may require.) The cable makes an angle of 30° with the horizontal rod.



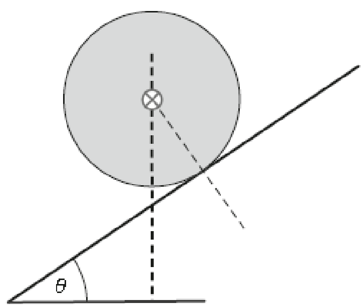
a Calculate:

i the tension in the cable **[3]**

ii the magnitude and direction of the force exerted by the wall on the rod. **[3]**

b A worker of mass 85 kg can walk anywhere on the rod without fear of the cable breaking. Determine the minimum breaking tension of the cable. **[3]**

2 A cylinder of mass $M = 12.0$ kg and radius $R = 0.20$ m rolls down an inclined plane without slipping.



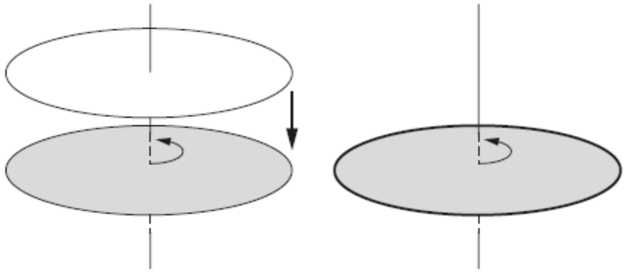
a Make a copy of the figure, and on it draw arrows to represent the forces acting on the cylinder as it rolls. **[3]**

b **i** Show that the linear acceleration of the centre of mass of the cylinder is $a = \frac{2}{3}g\sin\theta$. **[3]**

ii Determine the frictional force acting on the cylinder for $\theta = 30°$. **[1]**

c Calculate the rate of change of the angular momentum of the cylinder as it rolls for $\theta = 30°$. **[2]**

3 A horizontal disc rotates about a vertical axis through its centre of mass. The mass of the disc is 4.00 kg and its radius is 0.300 m. The disc rotates with an angular velocity of 42.0 rad s^{-1}. A ring of mass 2.00 kg and radius 0.300 m falls vertically and lands on top of the disc, as shown below. As the ring lands, it slides a bit on the disc and eventually the disc and ring rotate with the same angular velocity.



a **i** Explain why the angular momentum of the system is the same before and after the ring lands. **[2]**

ii Calculate the final angular velocity of the disc–ring system. **[3]**

iii Determine the kinetic energy lost as a result of the ring landing on the disc. **[3]**

b It took 3.00 s for the ring to start rotating with the same angular velocity as the disc.

i Determine the average angular acceleration experienced by the ring during this time. **[1]**

ii Calculate the number of revolutions made by the disc during the 3.00 s. **[2]**

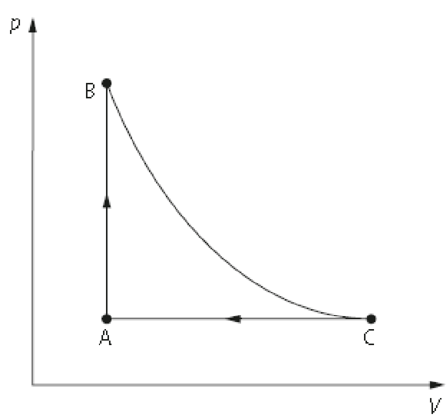
iii Show that the torque that accelerated the ring to its final constant angular velocity was 1.26 N m. **[2]**

iv State and explain, without further calculation, the magnitude of the torque that decelerated the disc. **[2]**

c Calculate the average power developed by the torque in **b iii** in accelerating the ring. **[2]**

4 A heat engine has 1.00 moles of an ideal gas as its working substance and undergoes the cycle shown below. BC is an adiabatic. The following data are available:

$T_A = 3.00 \times 10^2$ K, $p_A = 2.00 \times 10^5$ Pa, $T_B = 6.00 \times 10^2$ K



a Calculate:

i the pressure at B **[1]**

ii the temperature at C **[2]**

iii the volume at A and at C. **[2]**

b Determine:

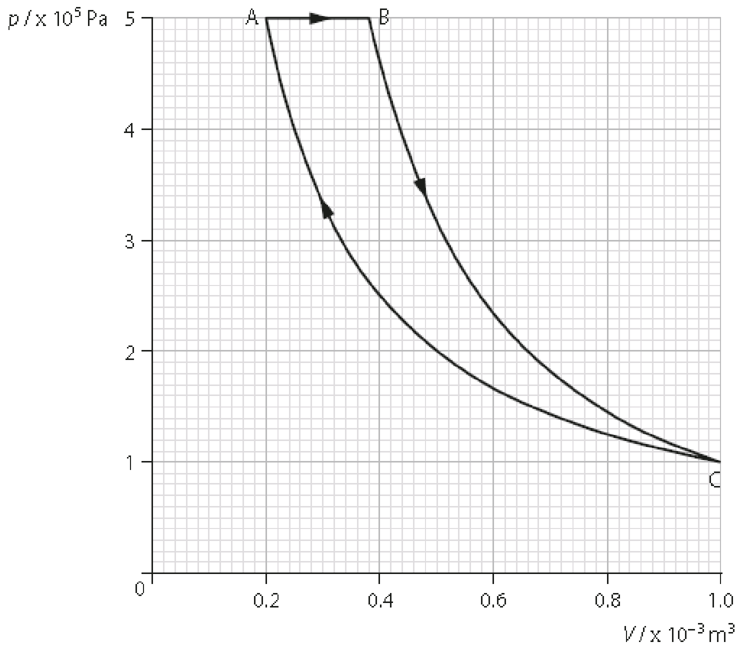
i the change in internal energy from A to B **[2]**

ii the energy removed from the gas. **[2]**

iii the efficiency of the cycle **[2]**

c State a version of the second law of thermodynamics in a way that directly applies to this engine. **[2]**

5 The graph shows a thermodynamic cycle in which an ideal gas expands from A to B to C and is then compressed back to A. BC is an adiabatic curve and CA is an isothermal curve. The volume at B is $0.38 \times 10^{-3}\,m^3$.



a **i** State what is meant by an **adiabatic curve**. **[1]**

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ii Explain why, in an adiabatic expansion of an ideal gas, temperature decreases. **[2]**

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b Justify why CA is isothermal. **[3]**

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c The temperature of the gas at A is 300 K.

i Calculate the temperature at B and at C. **[3]**

ii Determine the number of moles of the gas. **[2]**

d The work done from C to A is 160 J. Calculate:

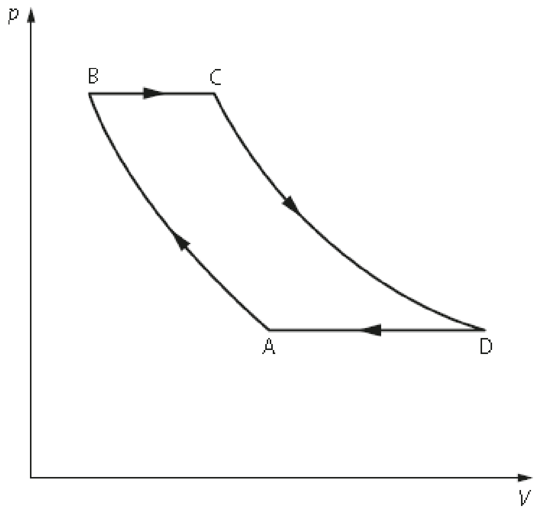
i the energy transferred out of the gas **[2]**

ii the energy transferred into the gas **[2]**

iii the work done from B to C **[2]**

iv the efficiency of the cycle. **[1]**

6 The graph shows the Brayton cycle (not drawn to scale), which consists of two isobaric and two adiabatic curves. The state at A has pressure 2.0×10^5 Pa, volume $0.40\,\text{m}^3$ and temperature 320 K. The pressure at B is 2.0×10^6 Pa.



a Show that, along an adiabatic curve, $\frac{T^5}{p^2} = \text{constant}$. **[3]**

b Calculate:

i the temperature at B **[2]**

ii the volume at B. **[2]**

c Show that the change in internal energy from A to B is 0.18 MJ. **[3]**

d Using your answer to **c**, determine the work done from A to B. **[2]**

7 a Show that the pressure at a depth h below the free surface of a liquid of density ρ is given by $p = p_0 + \rho g h$, where p_0 is atmospheric pressure.

b Suggest what, if anything, will happen to the pressure at a depth h below the free surface of the liquid in a container, if the container:

i is allowed to fall freely under gravity

ii is accelerated upwards with acceleration a.

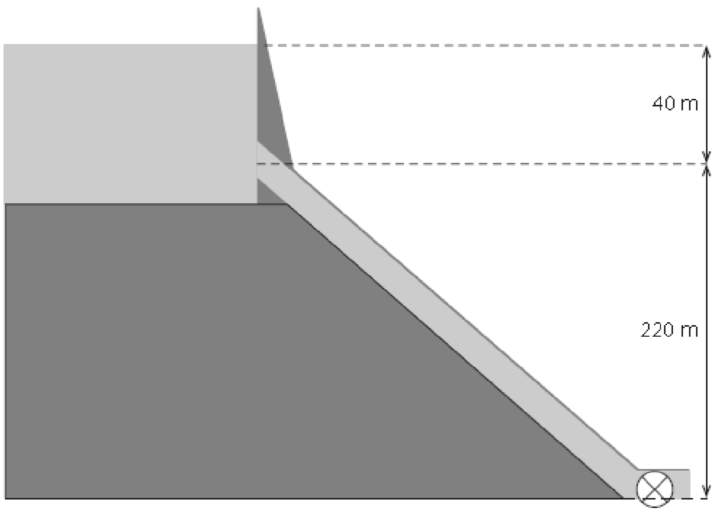
c State **Archimedes' principle**.

d A block of wood floats in water with 75% of its volume submerged. The same block when floating in oil has 82% of its volume submerged. The density of water is $1000\,\mathrm{kg\,m^{-3}}$. Calculate:

i the density of the wood

ii the density of the oil.

8 The diagram shows a hydroelectric power plant in which water from a large reservoir is allowed to flow down a long outlet pipe and, eventually, through a turbine. The radius of the outlet pipe where it leaves the reservoir is 65 cm, and it tapers down to 25 cm at the turbine. You may assume that the reservoir is large enough that there is no appreciable change in the water level of the reservoir as water flows out.



a **i** Calculate the speed of the water at the turbine. **[2]**

ii State two assumptions you have made in this calculation. **[2]**

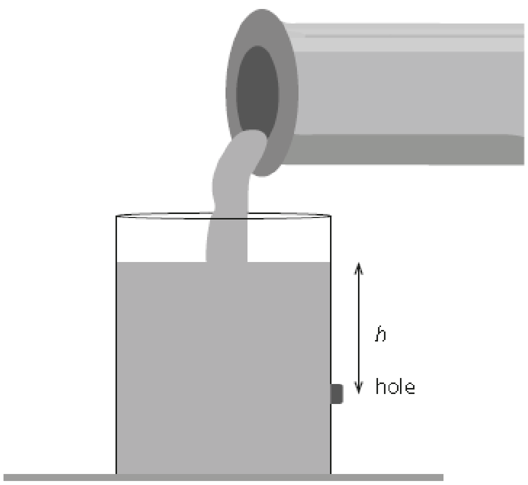
b Estimate the flow rate of the water though the turbine. **[2]**

c Calculate the water pressure at the upper end of the outlet pipe:

i when the water is static (i.e. not flowing) **[2]**

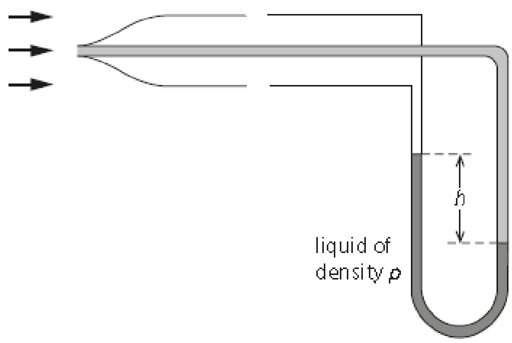
ii when the water is flowing. **[3]**

d In another, smaller reservoir, water is constantly being pumped into the reservoir at a rate of $0.40\,m^3\,s^{-1}$.



A hole of radius 3.0 cm is to be drilled at a depth *h* below the surface of the water such that, when the water flows out, the water level in the reservoir stays the same. Determine the depth *h*. **[3]**

9 A Pitot–Prandtl tube is used to measure the speed of an aircraft. The liquid in the manometer has density ρ and the difference in the levels of the liquid in the two columns is h.



a Explain why the liquid in the right-hand column of the manometer is lower than that in the left-hand column. **[2]**

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b Show that the flow speed v is given by $v = \sqrt{\dfrac{2\rho g h}{\rho_{air}}}$ **[3]**

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c This Pitot tube uses a liquid of density $\rho = 920\,\text{kg m}^{-3}$. The density of air is $1.20\,\text{kg m}^{-3}$ and the difference h in liquid levels is 0.25 m. Estimate the speed of the aircraft. **[2]**

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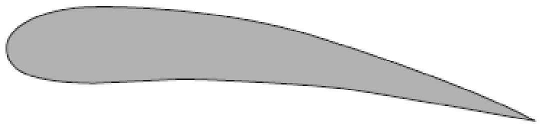
10 The diagram shows an aerofoil of **total** surface area $16\,m^2$. Air (of density $1.20\,kg\,m^{-3}$) flows with a speed of $85\,m\,s^{-1}$ across the upper surface of the aerofoil and a speed of $58\,m\,s^{-1}$ across the lower surface.



a On a copy of the diagram, draw streamlines around the aerofoil. **[2]**

b **i** Calculate the lifting force on the aerofoil. **[2]**

ii State one assumption you made in your calculation of the lifting force. **[1]**

c The weight of the aerofoil is 3.0 kN. The aerofoil is attached to the fuselage of an aircraft. Estimate the force that the aerofoil exerts on the fuselage. **[2]**

d If the aerofoil's angle relative to the horizontal is increased, the flow of air past it may become turbulent.

i State what is meant by turbulent flow. **[1]**

ii Indicate on your copy of the diagram the most likely position around the aerofoil where turbulence may set in. **[1]**

iii Suggest the effect of turbulence on the lifting force on the aerofoil. **[1]**

11 a Distinguish between **damped** and **undamped** oscillations. **[2]**

b The graph shows the variation with time of the displacement of an oscillating system.

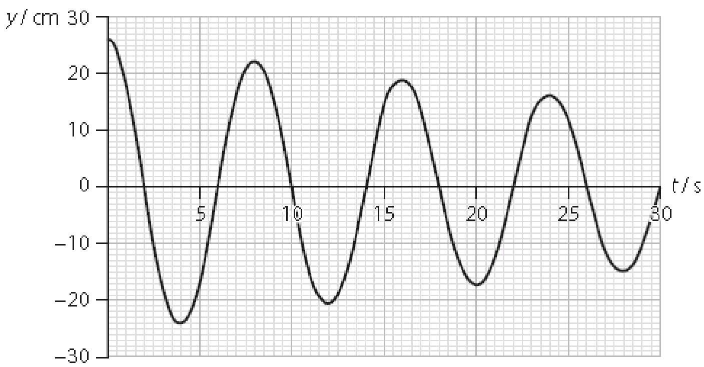


Figure B.110 For Exam-style question 11b.

Use the diagram to determine:

i the period of oscillation **[1]**

ii the Q factor of the system. **[3]**

c **i** On a copy of this diagram, draw a graph to show the variation of the displacement when the damping is increased. **[2]**

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ii State the effect, if any, of the increased damping on Q. **[1]**

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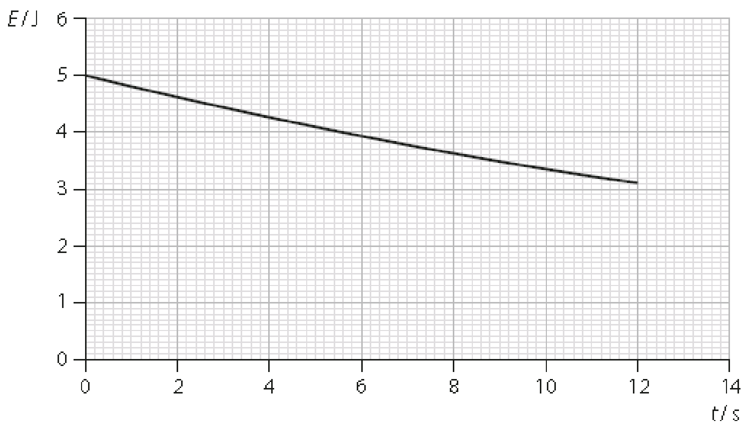
d The graph shows the variation with time of the energy of another oscillating system.



The system oscillates with a period of 2.0 s. Estimate the Q factor of this system. **[2]**

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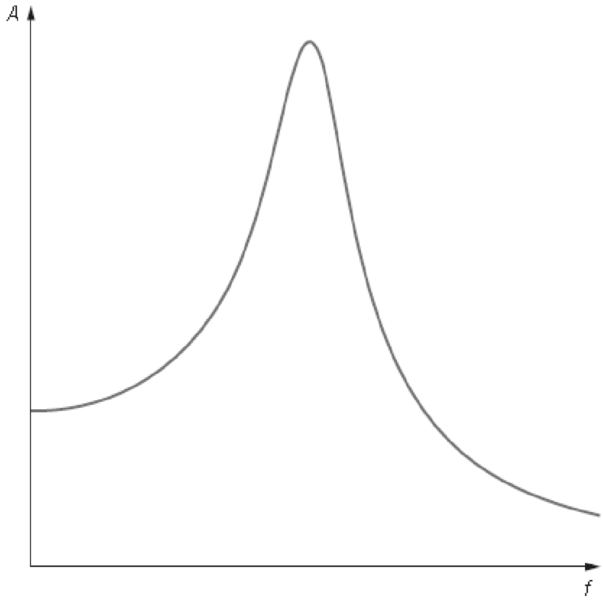
12 The graph shows the variation of the amplitude of an oscillating system with the frequency of a periodic force acting on the system. The system is lightly damped.



a By reference to the diagram, outline what is meant by resonance. **[3]**

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b On a copy of this diagram, sketch the variation of amplitude with frequency when the amount of damping is increased. **[2]**

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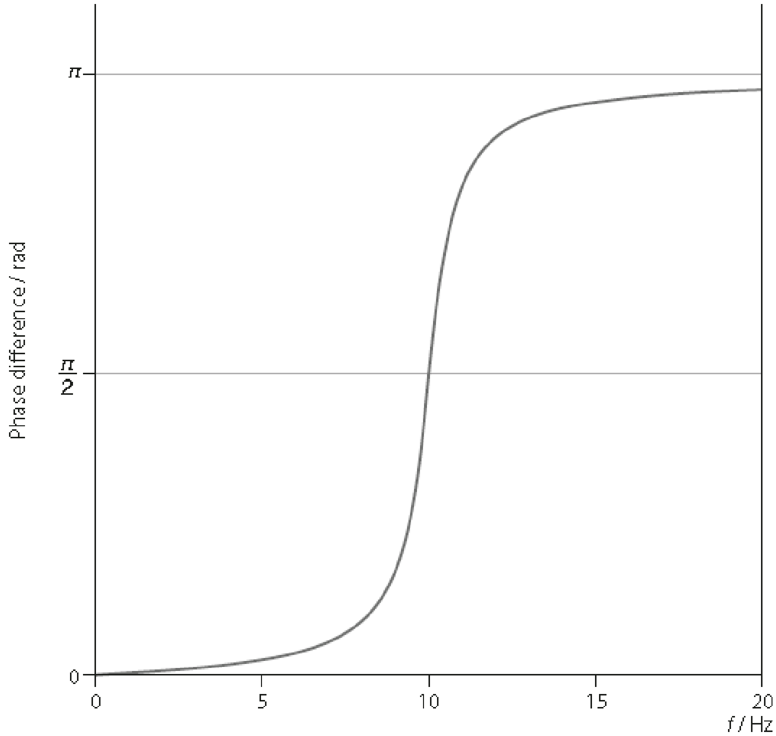
c The graph shows how the phase difference between the displacements of the system and the driver varies with the frequency of the driving force, for light damping.



i On a copy of this diagram, sketch a graph to show how the phase varies when the damping is increased. **[2]**

ii State the resonant frequency of this system. **[1]**