Physics
Higher level
Paper 1

IB Physics HL prediction paper 1

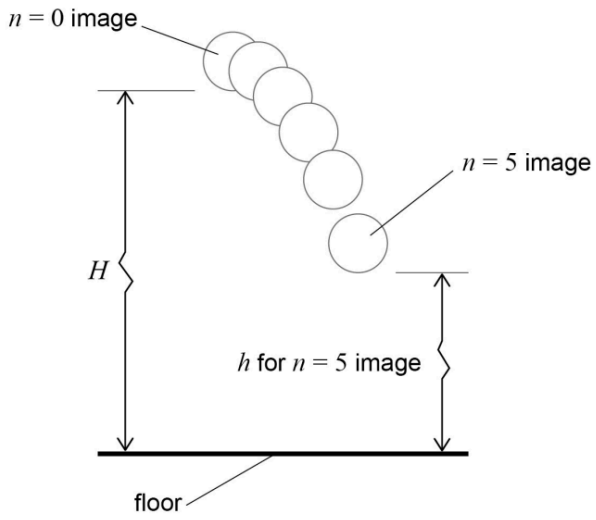
1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet (not provided).
- This product is an unofficial resource and is not affiliated with, endorsed by, or produced by the International Baccalaureate Organization (IBO).
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.

23 pages

1. The image shows six stroboscopic positions of a small ball released from rest, photographed at equal time intervals as it falls vertically towards the floor.



The flashes occur every 0.040 s. The vertical distance between the first image (n = 0) and the next (n = 1) is 7.8 cm. Neglecting air resistance, what is the magnitude of the vertical component of the ball's velocity at n = 0?

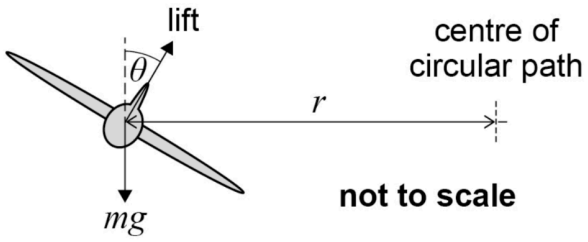
A. 0.36 m s^{-1}.

B. 1.8 m s^{-1}.

C. 2.5 m s^{-1}.

D. 3.4 m s^{-1}.

2. The image shows an aeroplane executing a level turn: its wings are banked so that the lift force makes an angle θ to the vertical toward the centre of a horizontal circular path of radius r.



Which expression gives the minimum speed v required to maintain this horizontal circular motion?

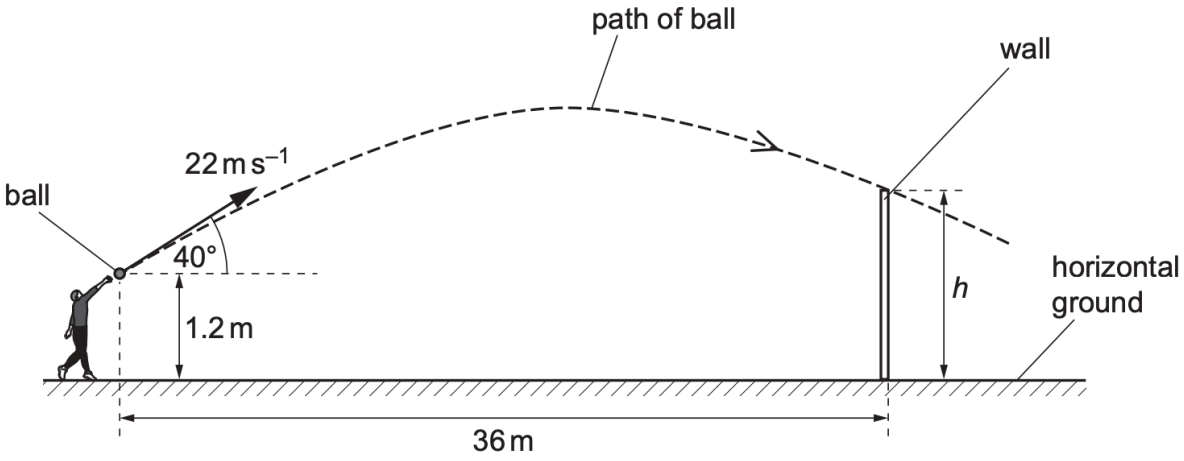
A. $v = \sqrt{(r\,g\,\tan\theta)}$

B. $v = \sqrt{(r\,g / \tan\theta)}$

C. $v = \sqrt{(r\,g\,\cot\theta)}$

D. $v = \sqrt{(r\,g\,\sin\theta)}$

3. The figure shows a ball launched at 22 m s^{-1} at 40° to the horizontal from a point 1.2 m above level ground towards a vertical wall 36 m away.



Assuming air resistance is negligible, what is the greatest height *h* (above the ground) that the top of the wall can have and still be cleared by the ball?

A. 5.2 m

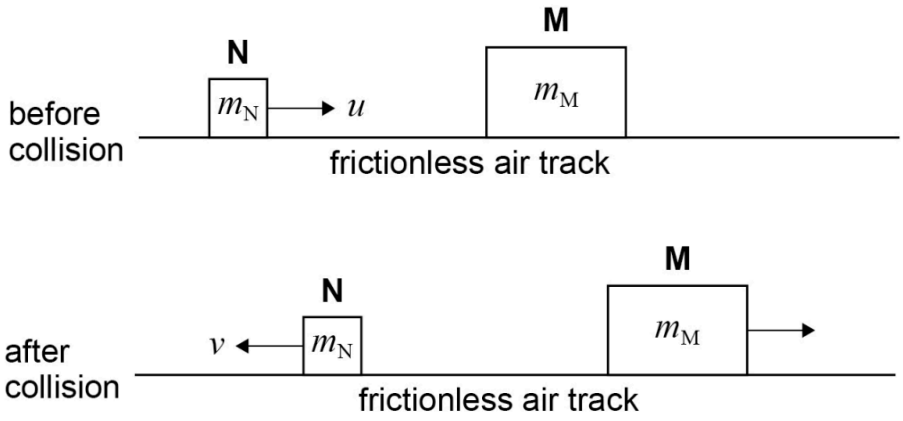
B. 7.3 m

C. 9.0 m

D. 11.4 m

Turn over

4. Two gliders on a friction-free track collide as shown. Glider **N** (mass 0.20 kg) moves at 0.50 m s^{-1} towards stationary glider **M** (mass 0.80 kg). After the collision **N** rebounds at 0.30 m s^{-1} in the opposite direction.



What is the speed of glider **M** immediately after the collision?

A. 0.10 m s^{-1}

B. 0.15 m s^{-1}

C. 0.20 m s^{-1}

D. 0.25 m s^{-1}

5. A 2.0 kg suitcase is lifted vertically at constant speed through 3.0 m. What is the work done against gravity? (g = 9.8 m s^{-2})

A. 6 J.

B. 20 J.

C. 59 J.

D. 120 J.

6. A crate of mass 25 kg is lifted vertically at constant speed through a height of 2.0 m in 4.0 s. What is the average power developed?

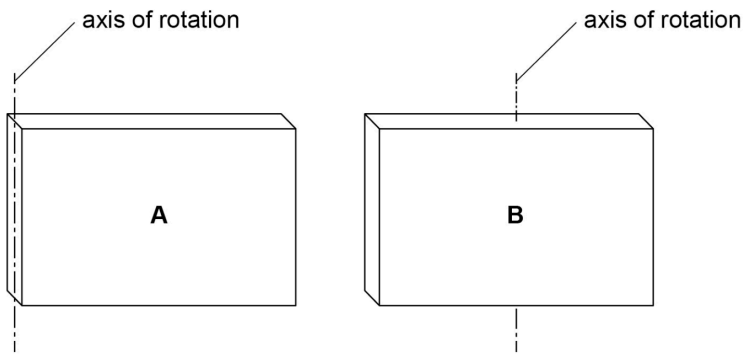
A. 6.1×10^{1} W

B. 1.2×10^{2} W

C. 2.5×10^{2} W

D. 9.8×10^{2} W

7. The figure shows two identical thin rectangular plates. Plate **A** is free to rotate about an axis along one edge; plate **B** rotates about an axis through its centre, both axes perpendicular to the plates.



Which statement correctly compares their moments of inertia about the indicated axes?

A. $I_A < I_B$

B. $I_A = I_B$

C. $I_A > I_B$

D. $I_A = \frac{1}{2} I_B$

8. A uniform solid disc of mass 3.0 kg and radius 0.20 m rotates freely about a horizontal axle through its centre. A thread is wrapped around the rim; a 0.50 kg mass is attached and allowed to fall 0.80 m before the thread detaches. Neglecting friction, what is the disc's angular speed just before detachment?

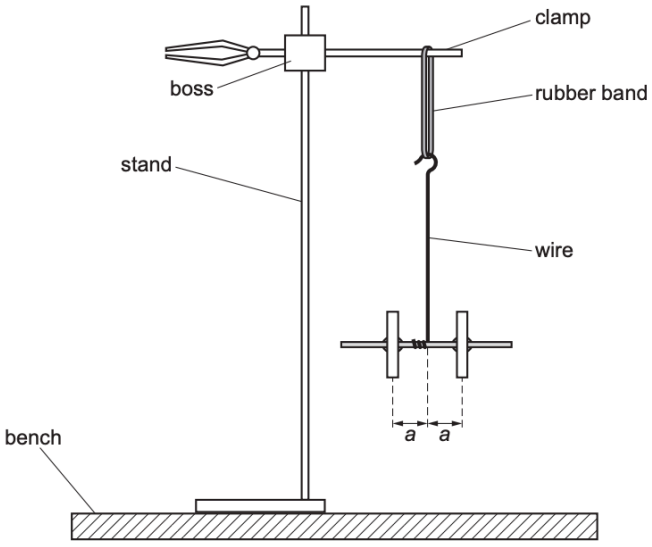
A. 5.0 rad s^{-1}

B. 7.0 rad s^{-1}

C. 9.9 rad s^{-1}

D. 14 rad s^{-1}

9. In the apparatus shown, a light horizontal rod carries two identical masses *m* each at distance *a* = 0.20 m from the supporting wire; the rod is horizontal and in equilibrium. One mass is replaced by a 10 % heavier mass 1.1 *m*, still at distance *a*.



To restore equilibrium, how far from the wire must the original mass *m* be moved along its side of the rod?

A. 0.18 m

B. 0.19 m

C. 0.22 m

D. 0.25 m

10. Muons produced high in the atmosphere travel at 0.98 c. Given the proper mean lifetime τ_0 = 2.2 μs, what average distance do they travel before decaying according to an observer on Earth?

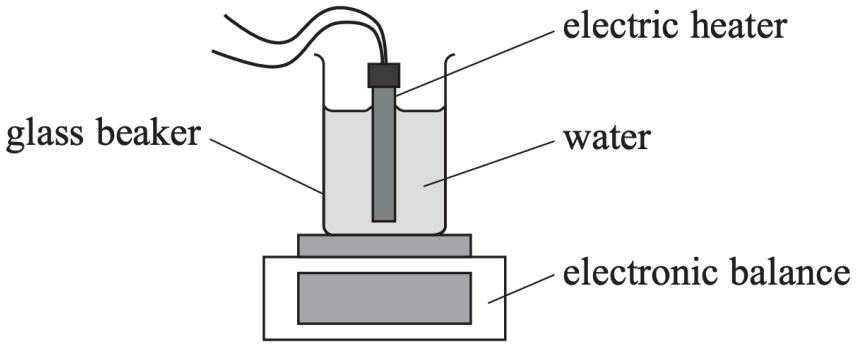
A. 0.65 km

B. 1.5 km

C. 3.3 km

D. 6.8 km

11. The image shows a beaker of water on a balance with an immersed electric heater used to determine the specific latent heat of vaporisation.



The heater supplies a constant power of 120 W for 5.0 min and the balance records a mass loss of 34 g. What experimental value of the specific latent heat L of water is obtained?

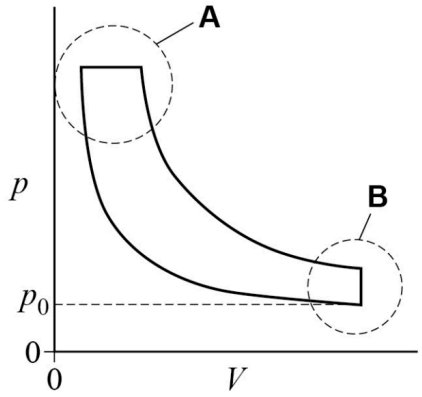
A. 1.1×10^6 J kg^{-1}

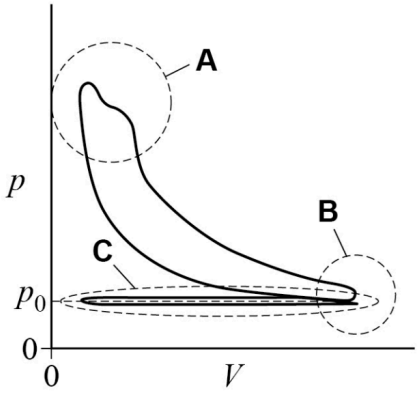
B. 2.3×10^6 J kg^{-1}

C. 3.6×10^5 J kg^{-1}

D. 8.5×10^6 J kg^{-1}

12. The image compares a theoretical (left) and a real (right) diesel-engine p-V diagram; points A and B on the theoretical cycle are highlighted.





p_0 is atmospheric pressure.

During the isothermal compression from A to B the working gas behaves ideally. At A the volume is V and the pressure is 8.0×10^5 Pa. At B the volume is 4 V. What is the pressure at B?

A. 2.0×10^5 Pa

B. 3.2×10^5 Pa

C. 8.0×10^6 Pa

D. 4.0×10^5 Pa

13. An ideal diatomic gas ($\gamma = 1.4$) is compressed adiabatically and reversibly from volume V to ½ V. If the initial temperature is 300 K, what is the final temperature?

A. 330 K

B. 360 K

C. 450 K

D. 400 K

14. A Carnot engine operates between a hot reservoir at 600 K and a cold reservoir at 300 K. What is the maximum possible efficiency?

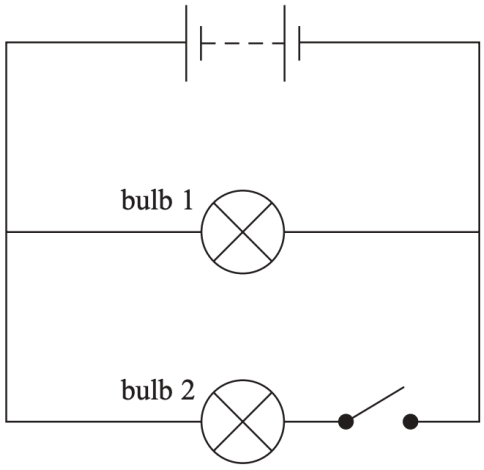
A. 0.50

B. 0.33

C. 0.25

D. 2.0

15. The circuit shows a 12 V battery of internal resistance 0.50 Ω connected to two identical 40 W, 12 V lamps. Lamp 2 can be switched in parallel with lamp 1.



With **both** lamps switched on, what is the power dissipated in **each** lamp?

A. 16 W

B. 25 W

C. 33 W

D. 40 W

16. A 12 V battery with internal resistance 0.40 Ω is connected to a 5.6 Ω resistor. What power is dissipated in the resistor?

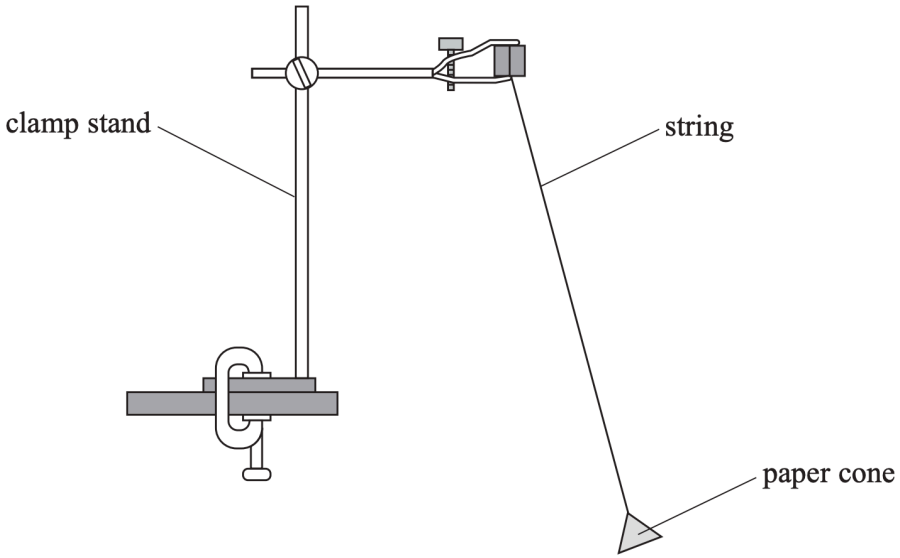
A. 18 W

B. 20 W

C. 22 W

D. 25 W

17. The image shows a paper-cone pendulum suspended from a clamp; the length of the string is 0.90 m.



Ignoring air resistance, what is the period of small oscillations? ($g = 9.8\ m\ s^{-2}$)

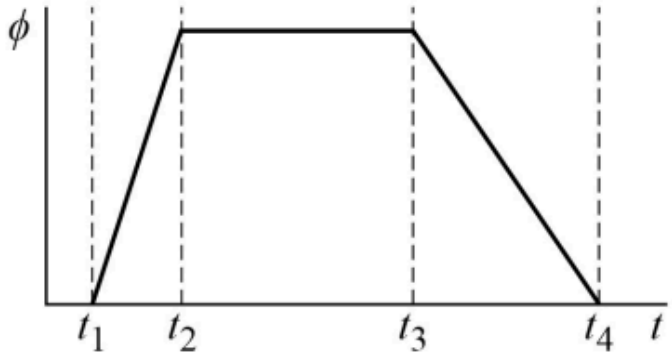
A. 0.60 s

B. 1.9 s

C. 1.3 s

D. 6.0 s

18. The diagram shows one cycle of an electromagnetic wave travelling in the +x-direction. The instantaneous electric field **E** is along the +y-axis and the magnetic field **B** is along the +z-axis.



Which statement correctly distinguishes this wave from a sound wave travelling through air?

A. The electromagnetic wave transports energy but the sound wave does not.

B. The electromagnetic wave requires a medium for propagation whereas the sound wave does not.

C. The electromagnetic wave frequency is independent of the source but the sound wave frequency is not.

D. The electromagnetic wave can be polarised whereas the sound wave cannot.

19. Young's double slits are 0.30 mm apart and illuminated by light of wavelength 600 nm. What is the angular separation between adjacent bright fringes on a distant screen?

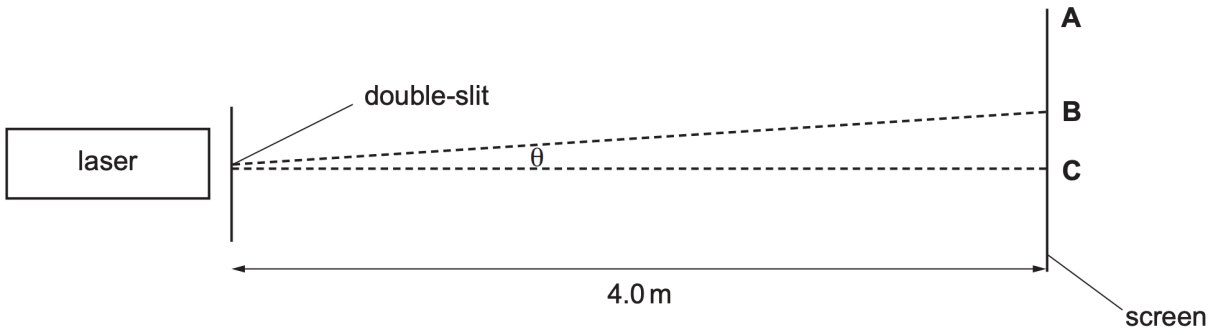
A. 2.0×10^{-4} rad

B. 2.0×10^{-3} rad

C. 2.0×10^{-2} rad

D. 2.0×10^{-1} rad

20. The image depicts a laser beam incident on a double slit; bright fringes appear on a screen 4.0 m away. The distance between successive bright fringes is 3.2 mm; the slit separation is 0.25 mm.



What is the wavelength of the laser light?

A. 2.0×10^{-7} m

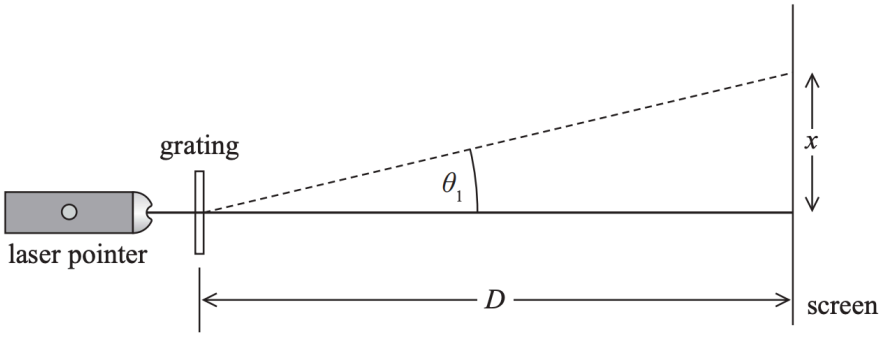
B. 6.3×10^{-7} m

C. 8.0×10^{-7} m

D. 1.3×10^{-6} m

Turn over

21. A student directs monochromatic light normally onto a diffraction grating, as illustrated. The first-order maximum is observed a vertical distance *x* above the central maximum on a screen distance *D* from the grating.



Which expression gives the wavelength λ of the light?

A. $\lambda = xD / (D^2 + x^2)$

B. $\lambda = x / D$

C. $\lambda = x / \sqrt{(D^2 + x^2)}$

D. $\lambda = x / \sqrt{(D^2 - x^2)}$

22. The photograph shows a cello being played. The vibrating length of one string between the bridge and the nut is 0.68 m. When it vibrates in its fundamental mode the frequency produced is 196 Hz.

(Source: © Vadim Ponomarenko/Alamy Stock Photo)

Assuming the tension in the string remains unchanged, what is the frequency of the second overtone (third harmonic) of this string?

A. $\lambda = xD / (D^2 + x^2)$

B. $\lambda = x / D$

C. $\lambda = x / \sqrt{(D^2 + x^2)}$

D. $\lambda = x / \sqrt{(D^2 - x^2)}$

23. An ambulance siren emits 700 Hz. It moves towards a stationary observer at 30 m s^{-1}. Taking the speed of sound as 340 m s^{-1}, what frequency does the observer hear?

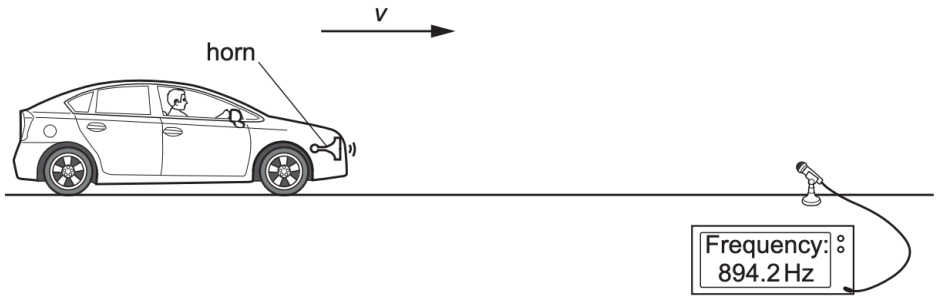
A. 640 Hz

B. 700 Hz

C. 770 Hz

D. 800 Hz

24. A car sounding its horn (emitted frequency f_s = 800 Hz) drives directly towards a stationary microphone, as shown. The speed of sound in air is 340 m s^{-1}.



When the microphone registers a frequency of 894 Hz, what is the speed v of the car?

A. 17 m s^{-1}

B. 36 m s^{-1}

C. 42 m s^{-1}

D. 68 m s^{-1}

25. A planet has mass 4.0×10^{23} kg and radius 1.6×10^{6} m. What is the escape speed from its surface? ($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})

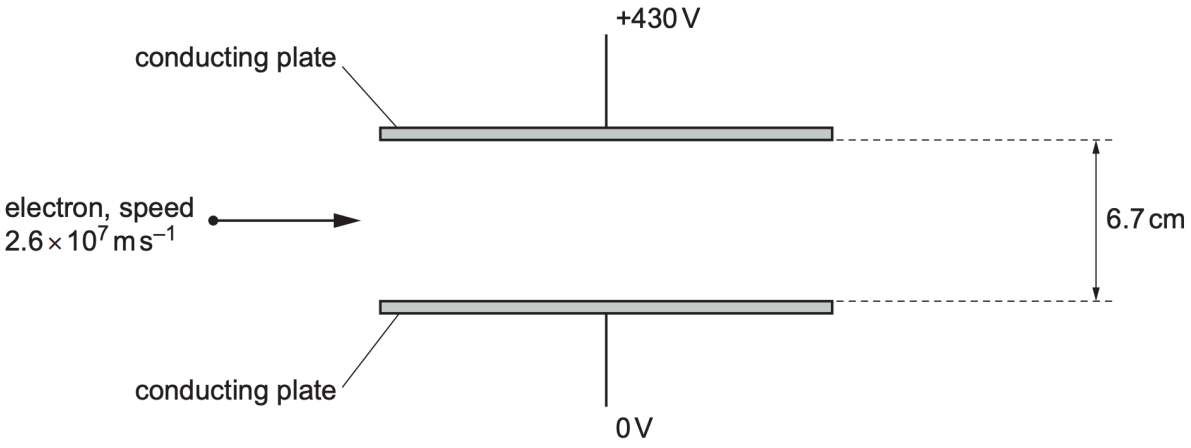
A. 2.9 km s^{-1}

B. 4.1 km s^{-1}

C. 5.8 km s^{-1}

D. 8.2 km s^{-1}

26. The image shows two parallel plates separated by 6.7 cm with a potential difference of 430 V.



What is the magnitude of the electric field strength between the plates?

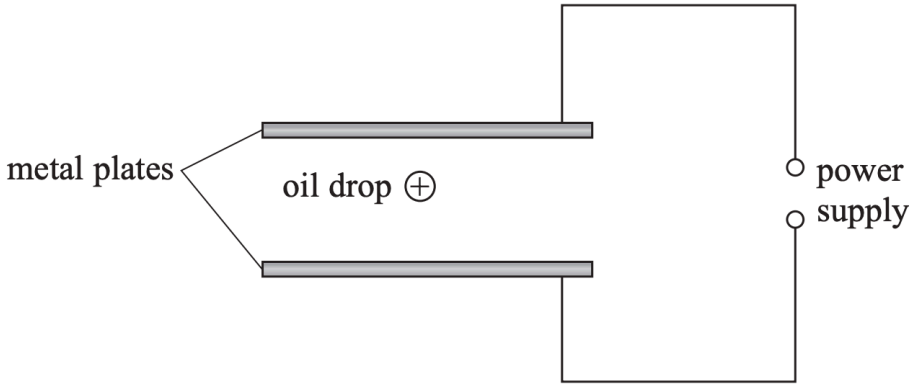
A. 6.4 V m^{-1}

B. 29 V m^{-1}

C. 6.4 × 10^2 V m^{-1}

D. 2.9 × 10^4 V m^{-1}

27. In a Millikan-type setup an oil drop of mass 1.6×10^{-15} kg is held stationary between two horizontal plates 5.0 mm apart by a uniform electric field produced by a 450 V potential difference.



What is the charge q on the drop?

A. 1.1×10^{-19} C

B. 1.6×10^{-19} C

C. 1.7×10^{-18} C

D. 4.9×10^{-18} C

28. Singly ionised neon-20 ions (mass 3.3×10^{-26} kg, charge +e) enter a 0.20 T magnetic field perpendicular to their velocity and describe a semicircle of diameter 0.12 m before leaving the field. What is the kinetic energy of the ions on entry?

A. 35 eV

B. 3.5×10^{2} eV

C. 3.5×10^{3} eV

D. 3.5×10^{4} eV

29. A coil with 200 turns encloses an area of 0.015 m². The perpendicular magnetic field increases uniformly from 0.10 T to 0.30 T in 0.40 s. What is the average induced emf?

A. 0.75 V

B. 6.0 V

C. 3.0 V

D. 1.5 V

30. A transformer steps up 120 V ac to 3.0 kV with 95 % efficiency. If the primary draws 4.0 A, what is the secondary current?

A. 0.015 A

B. 0.050 A

C. 0.15 A

D. 0.60 A

31. Earth's surface at 288 K emits radiation with a peak wavelength λ_{max} given by Wien's law:

λ_{max} T = b (b = 2.9 × 10^{-3} m K).

Which wavelength range is most strongly absorbed by atmospheric CO_2, enhancing the greenhouse effect?

A. 0.3 μm – 0.8 μm (visible).

B. 0.8 μm – 4 μm (near-IR).

C. 4 μm – 20 μm (thermal IR).

D. 100 μm – 1000 μm (microwave).

32. Using $R = R_0 A^{(1/3)}$ with $R_0 = 1.2$ fm, what is the approximate nuclear radius of ^{197}Au?

A. 4.6 fm

B. 6.0 fm

C. 7.0 fm

D. 9.5 fm

33. A metal has work function 2.3 eV. Ultraviolet light of wavelength 350 nm is incident. What is the maximum kinetic energy of emitted photoelectrons?

A. 1.2 eV

B. 0.5 eV

C. 2.3 eV

D. 3.5 eV

34. An electron is accelerated from rest through a potential difference of 150 V. What is its de Broglie wavelength?

A. 0.01 nm

B. 0.10 nm

C. 1.0 nm

D. 10 nm

35. A sample initially contains 1.00×10^{6} nuclei of a radionuclide. After 10 days, 6.25×10^{5} nuclei remain undecayed. What is the half-life of the radionuclide?

A. 6.0 days.

B. 10 days.

C. 15 days.

D. 20 days.

36. Each fission of ^{235}U releases 200 MeV. A reactor produces 1.5 GW of thermal power. Approximately how many fissions occur each second?

A. 4.7×10^{18}

B. 4.7×10^{19}

C. 4.7×10^{20}

D. 4.7×10^{21}

37. Why does energy release when four protons fuse to form a helium-4 nucleus in main-sequence stars?

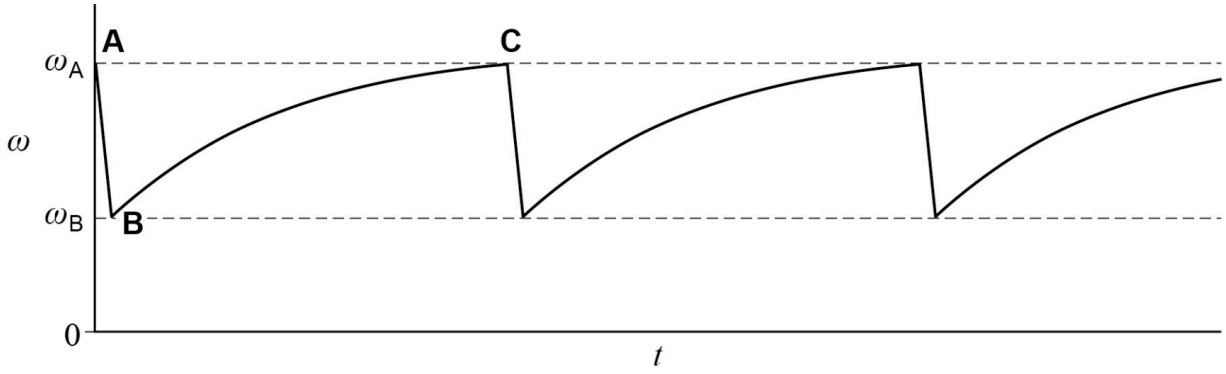
A. Helium has a greater binding energy per nucleon than hydrogen.

B. Helium’s mass is less than the combined proton mass because electrons are removed.

C. Gravitational potential energy is converted directly into nuclear energy.

D. Proton-proton electrostatic repulsion increases the energy of the helium nucleus.

38. The figure shows the variation of angular velocity ω of a flywheel. Between points **B** and **C** its speed rises from ω_β = 120 rad s^{-1} to ω_a = 160 rad s^{-1} in 8.0 s. The flywheel's moment of inertia is 150 kg m^2.



What is the average power supplied by the motor during BC?

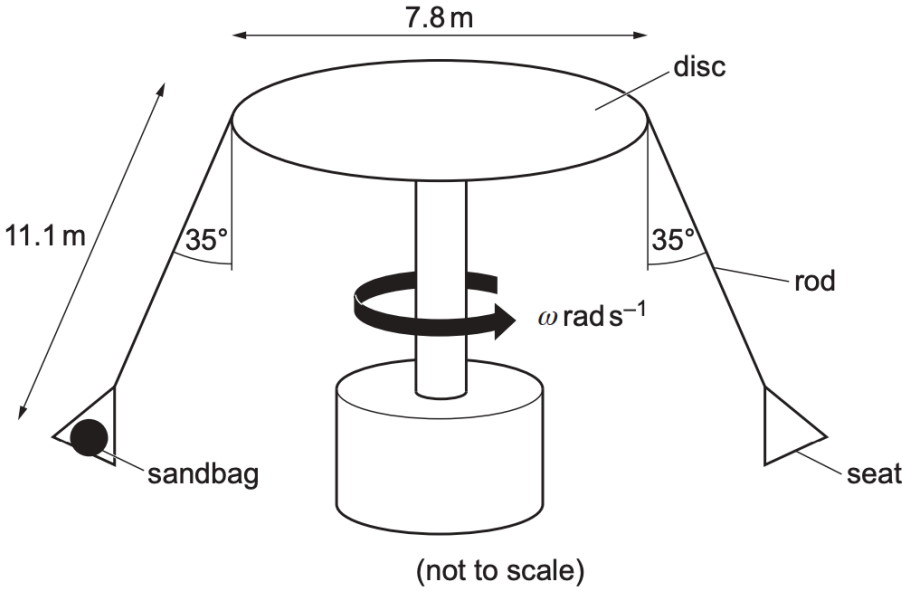
A. 4.0×10^4 W

B. 7.0×10^4 W

C. 1.05×10^5 W

D. 2.1×10^5 W

39. The diagram shows a chair-swing ride. Each 12 kg seat is attached to the edge of a horizontal disc of diameter 7.8 m by a rigid 11.1 m rod. When operating, the rod makes a steady 35° angle to the vertical.



Assuming uniform circular motion, what is the angular speed ω of the system?

A. 4.0×10^4 W

B. 7.0×10^4 W

C. 1.05×10^5 W

D. 2.1×10^5 W

40. In a thermal nuclear reactor using ^{235}U, fission is most commonly initiated by the absorption of which particle?

A. Alpha particle.

B. Beta particle.

C. Thermal neutron.

D. Gamma photon.