3IB Physics. Hand in Jan. 2009 TM – *include working!*

1. M05 TZ1 S1, H1: 1

The order of magnitude of the weight of an apple is

A. 10^{-4} N.

B. 10^{-2} N.

C. 1 N.

D. 10^{2} N.

2. M05 TZ1 S1:3, H1: 2

The reading of a constant potential difference is made four times by a student. The readings are

1.176 V
1.178 V
1.177 V
1.176 V.

The student averages these readings but does not take into account the zero error on the voltmeter.

The average measurement of the potential difference is

A. precise and accurate.

B. precise but not accurate.

C. accurate but not precise.

D. not accurate and not precise.

3. M05 TZ1 H1: 17

A liquid is evaporating, causing the liquid to cool.

The temperature of the liquid decreases because

A. the number of liquid molecules is decreasing.

B. the mean kinetic energy of the liquid molecules is decreasing.

C. the pressure above the liquid surface is increasing.

D. the rate of evaporation is increasing.

4. M05 TZ1 S1:4

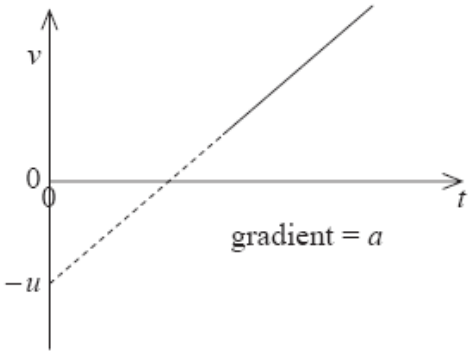
The variation with time t of the speed v of an object is given by the expression

$$v = u + at$$

where u and a are constants.

A graph of the variation with time t of speed v is plotted. Which **one** of the following correctly shows how the constants may be determined from this graph?

A.



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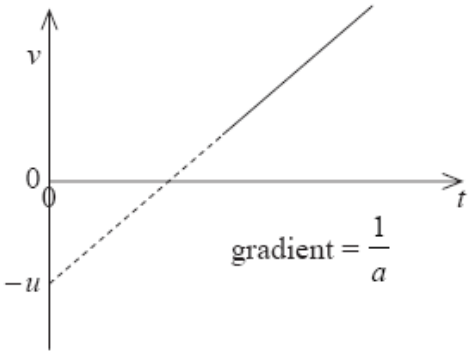
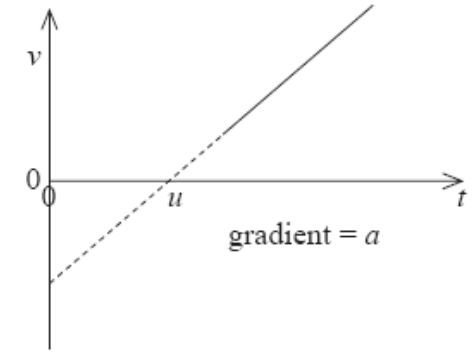
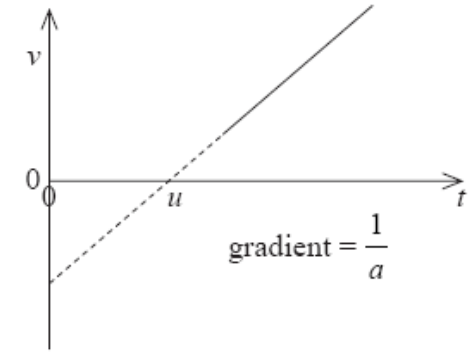


C.



D.



5. M05 TZ1 H1: 8

A general expression for Newton's second law of motion is

$$F = \frac{\Delta p}{\Delta t}.$$

What condition is applied so that the law may be expressed in the form $F = ma$?

A. The mass m is constant.

B. The acceleration a is constant.

C. The force F is constant.

D. The direction of the force F is constant.

6. M05 TZ1 H1: 4

The volume V of a cylinder of height h and radius r is given by the expression

$$V = \pi r^2 h.$$

In a particular experiment, r is to be determined from measurements of V and h. The uncertainties in V and in h are as shown below.

V	± 7 %
h	± 3 %

The approximate uncertainty in r is

A. 10 %.

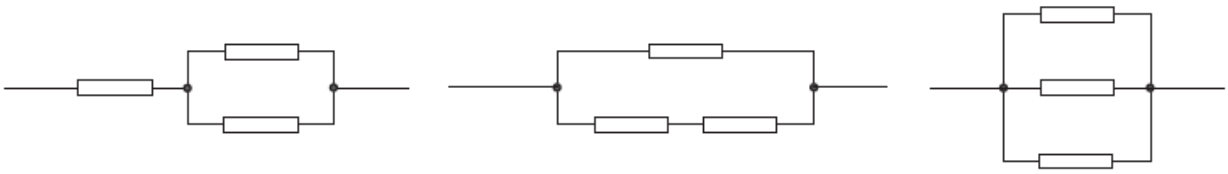
B. 5 %.

C. 4 %.

D. 2 %.

7. M05 TZ1 S1:24

The diagrams below show combinations X, Y and Z of three resistors, each resistor having the same resistance.



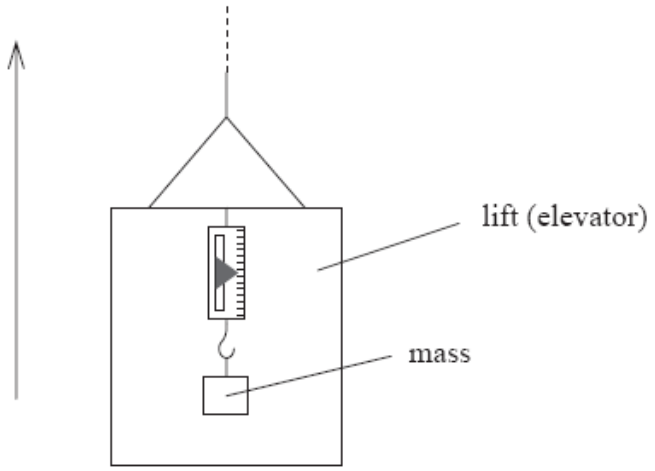
combination X combination Y combination Z

Which **one** of the following shows the resistances of the combinations in increasing order of magnitude?

	lowest	→	**highest**
A.	Y	X	Z
B.	Z	X	Y
C.	X	Y	Z
D.	Z	Y	X

8. M05 TZ1 S1:9

A mass is suspended from the roof of a lift (elevator) by means of a spring balance, as illustrated below.



The lift (elevator) is moving upwards and the readings of the spring balance are noted as follows.

Accelerating: R_a

Constant speed: R_c

Slowing down: R_s

Which **one** of the following is a correct relationship between the readings?

A. $R_a > R_c$

B. $R_a = R_s$

C. $R_c = R_s$

D. $R_c < R_s$

9. M05 TZ1 S1:16

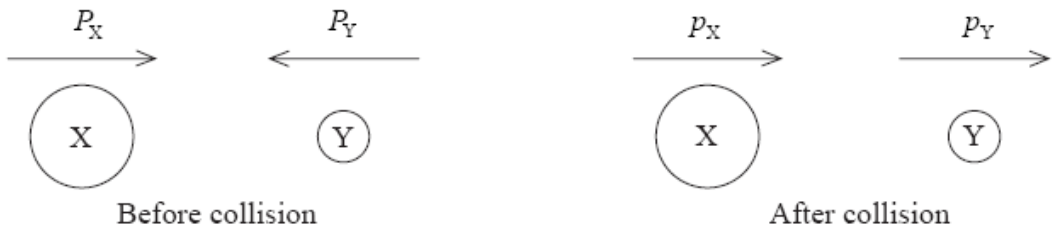
A liquid is contained in a dish open to the atmosphere.

Which **one** of the following contains three factors that affect rate of evaporation of the liquid?

A.	Temperature of the liquid	Surface area	Specific latent heat of vaporisation
B.	Temperature of the liquid	Mass of liquid	Specific latent heat of vaporisation
C.	Surface area	Mass of liquid	Temperature of the liquid
D.	Mass of liquid	Surface area	Specific latent heat of vaporisation

10. M05 TZ1 S1:10

Two spheres X and Y are moving towards each other along the same straight line with momenta of magnitude P_X and P_Y respectively. The spheres collide and move off with momenta p_X and p_Y respectively, as illustrated below.



Which **one** of the following is a correct statement of the law of conservation of momentum for this collision?

A. $P_X + P_Y = p_X + p_Y$

B. $P_X - P_Y = p_X + p_Y$

C. $P_X - P_Y = p_X - p_Y$

D. $P_X + P_Y = p_X - p_Y$

11. M05 TZ1 S1:28

Ag-102, Ag-103 and Ag-104 are three isotopes of the element silver.

Which **one** of the following is a true statement about the nuclei of these isotopes?

A. All have the same mass.

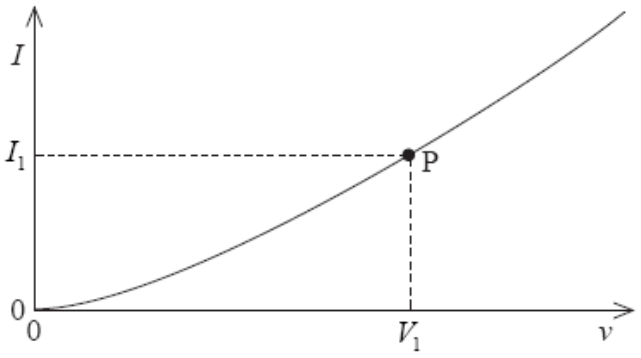
B. All have the same number of nucleons.

C. All have the same number of neutrons.

D. All have the same number of protons.

12. M05 TZ1 S1:23, H1: 29

The graph shows the variation with applied potential difference V of the current I in an electrical component.



Which **one** of the following gives the resistance of the component at point P?

A. The gradient of the line at P

B. The reciprocal of the gradient of the line at P

C. The ratio $\frac{I_1}{V_1}$

D. The ratio $\frac{V_1}{I_1}$

13. M05 TZ1 H1:34

The number of nucleons in a nucleus is the number of

A. particles in the nucleus.

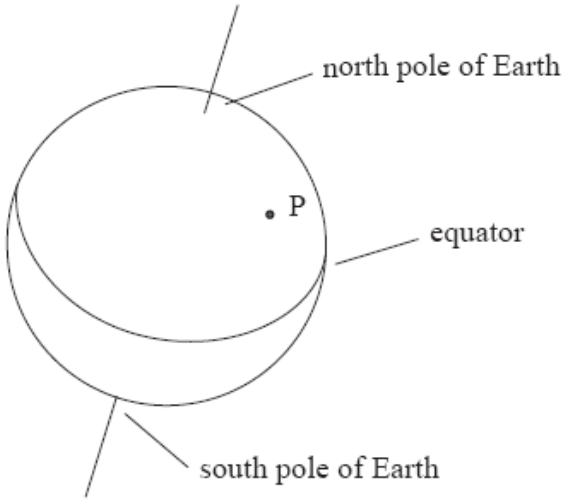
B. neutrons in the nucleus.

C. protons in the nucleus.

D. protons plus neutrons in the nucleus.

14. M05 TZ1 S1:26

The diagram below shows a point P on the Earth's surface at which a compass needle is suspended freely.



Which **one** of the following gives the correct direction in which the needle of the compass will point?

	Plane of compass needle	Direction of north pole of compass
A.	Horizontal	Towards north pole of Earth
B.	Horizontal	Towards south pole of Earth
C.	At an angle to the horizontal	Towards north pole of Earth
D.	At an angle to the horizontal	Towards south pole of Earth

15. M05 TZ1 S1:30, H1: 36

A freshly-prepared sample of cobalt-64 $\left({}^{64}_{27}\mathrm{Co}\right)$ decays by the emission of γ-ray photons. The decay may be represented by the nuclear equation

$$ {}^{64}_{27}\mathrm{Co} \rightarrow {}^{64}_{27}\mathrm{Co} + \text{energy}. $$

After this decay, the binding energy per nucleon has

A. increased in magnitude because energy has been emitted from the nucleus.

B. decreased in magnitude because energy has been emitted from the nucleus.

C. stayed constant because the number of nucleons in the nucleus is unchanged.

D. stayed constant because the proton number is unchanged.

16. M05 TZ1 H2: A4

This question is about the photoelectric effect.

The following are two observations relating to the emission of electrons from a metal surface when light of different frequencies and different intensities is incident on the surface.

I. There exists a frequency of light (the threshold frequency) below which no electrons are emitted whatever the intensity of the light.

II. For light above the threshold frequency, the emission of the electrons is instantaneous whatever the intensity of the light.

Explain why the wave model of light is unable to account for these observations. *[6]*

Observation I . . . . . .

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Observation II . . . . . .

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17. M05 TZ1 S2:B2p1, H2: B1p1

Part 1 Momentum and kinematics

(a) State the law of conservation of momentum. *[2]*

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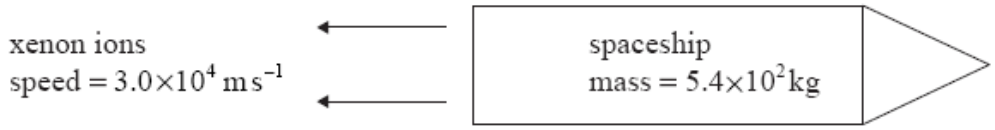
A solar propulsion engine uses solar power to ionise atoms of xenon and to accelerate them. As a result of the acceleration process, the ions are ejected from the spaceship with a speed of $3.0\times10^{4}\,\mathrm{m\,s^{-1}}$.



(b) The mass (nucleon) number of the xenon used is 131. Deduce that the mass of one ion of xenon is $2.2\times10^{-25}\,\mathrm{kg}$. *[2]*

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(c) The original mass of the fuel is 81 kg. Deduce that, if the engine ejects 7.7×10^{18} xenon ions every second, the fuel will last for 1.5 years. (1 year = 3.2×10^{7}s) *[2]*

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(d) The mass of the spaceship is $5.4\times10^{2}\,\mathrm{kg}$. Deduce that the initial acceleration of the spaceship is $8.2\times10^{-5}\,\mathrm{m\,s^{-2}}$. *[5]*

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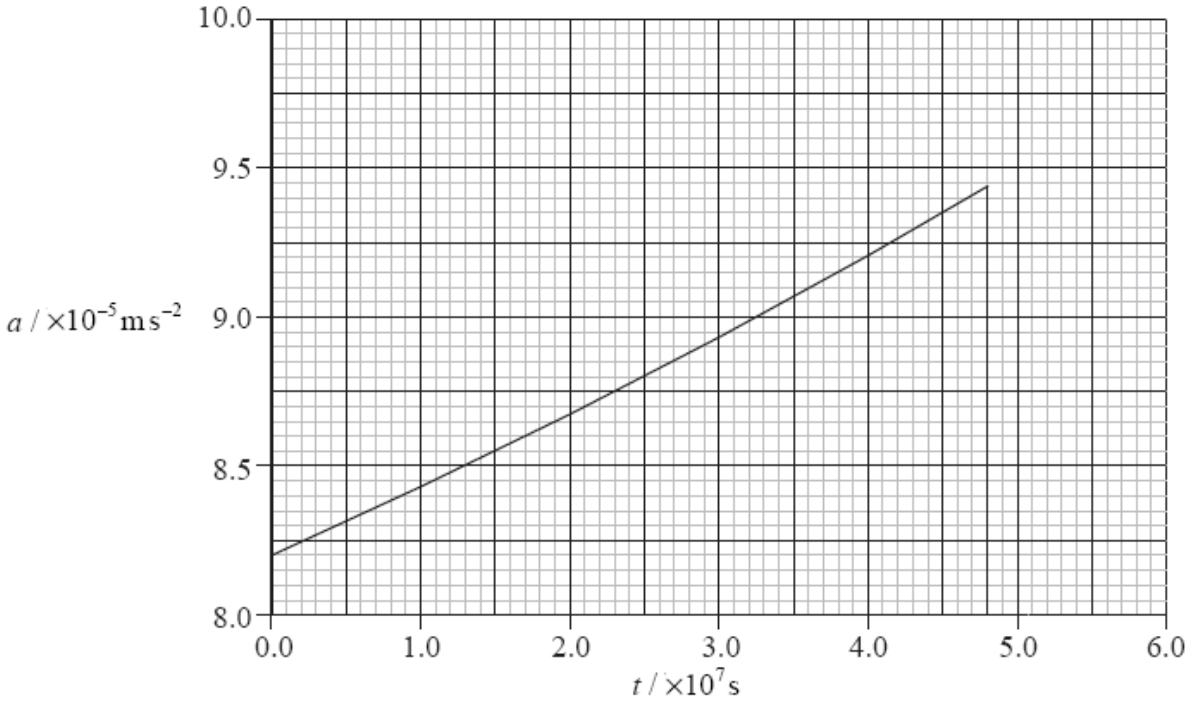
The graph below shows the variation with time t of the acceleration a of the spaceship. The solar propulsion engine is switched on at time $t = 0$ when the speed of the spaceship is $1.2\times10^{3}\,\mathrm{m\,s^{-1}}$.



(e) Explain why the acceleration of the spaceship is increasing with time. *[2]*

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(f) Using data from the graph, calculate the speed of the spaceship at the time when the xenon fuel has all been used. *[4]*

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(g) The distance of the spaceship from Earth when the solar propulsion engine is switched on is very small compared to the distance from Earth to Jupiter. The fuel runs out when the spaceship is a distance of 4.7×10^{11} m from Jupiter. Estimate the total time that it would take the spaceship to travel from Earth to Jupiter. *[2]*

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The reminder of this paper is HL only

18. M04 TZ1 S1:17, H1:18

The equation of state of an ideal gas is

$$pV = nRT.$$

In this equation, the constant n is the number of

A. atoms in the gas.

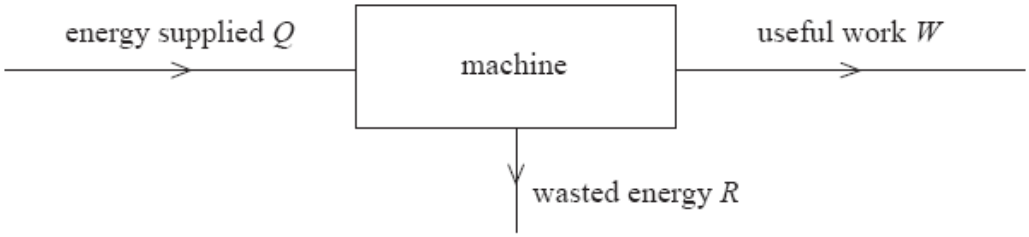
B. molecules in the gas.

C. particles in the gas.

D. moles of the gas.

19. M04 TZ1 H1:10

An amount Q of energy is supplied to a machine. The machine does useful work W and an amount R of energy is wasted, as illustrated below.



Which **one** of the following is a correct expression for the efficiency of the machine?

A. $\frac{W}{Q}$

B. $\frac{R}{Q}$

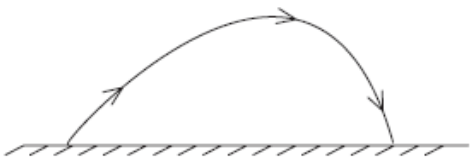
C. $\frac{W+R}{Q}$

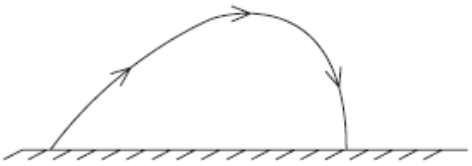
D. $\frac{W-R}{Q}$

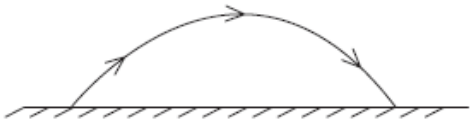
20. M04 TZ1 H1:12

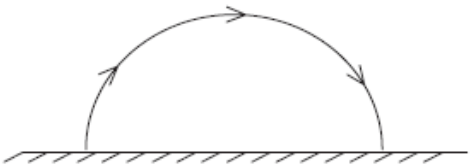
A boy throws a small stone at an angle to the horizontal.

Which **one** of the following sketches best shows the path of the stone as it rises and then falls back to Earth? Air resistance is negligible and the acceleration of free fall is constant.

A. 

B. 

C. 

D. 

21. M04 TZ1 H1:14

An isolated point object has mass M. A second small point object of mass m is placed a distance x from the larger mass.

Which **one** of the following is a correct expression for the gravitational potential energy of the mass m?

A. $-\frac{GM}{x}$

B. $-\frac{GMm}{x}$

C. $-\frac{GM}{x^2}$

D. $-\frac{GMm}{x^2}$

22. M04 TZ1 H1:32

Faraday's law of electromagnetic induction states that the induced e.m.f. is

A. proportional to the change in magnetic flux linkage.

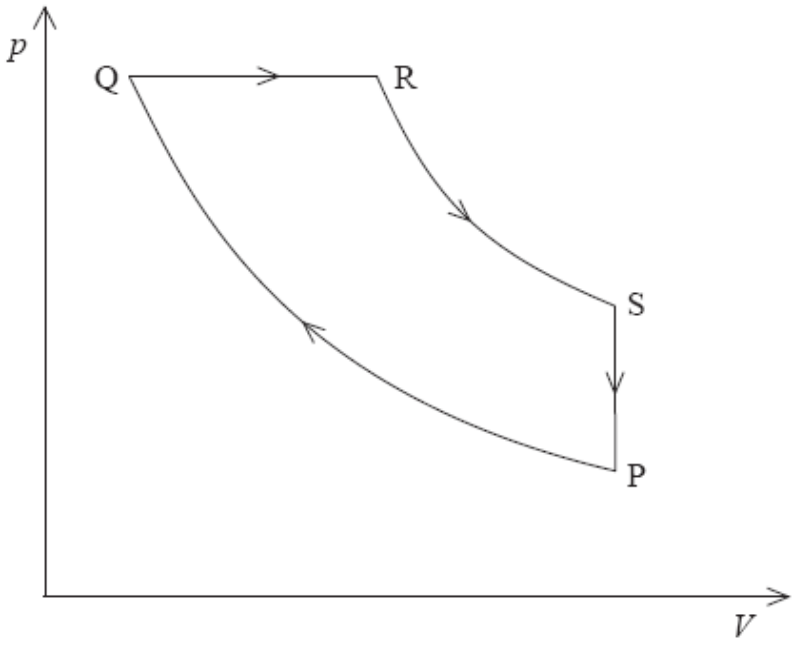
B. proportional to the rate of change of magnetic flux linkage.

C. equal to the change in magnetic flux linkage.

D. equal to the change of magnetic flux.

23. M04 TZ1 H1:19

The diagram shows the pressure / volume (p/V) diagram for one cycle PQRS of an engine.



In which sections of the cycle is work done **on** the engine?

24. M04 TZ1 H1:20

A Carnot engine operates between two thermal reservoirs. The thermodynamic temperature of the higher-temperature reservoir is T_H and of the lower, T_L.

Which **one** of the following is a correct expression for the efficiency of the engine?

A. $\frac{T_H}{T_L}$

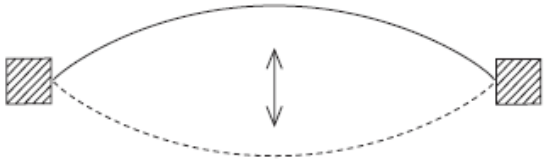
B. $\frac{T_L}{T_H}$

C. $1-\left(\frac{T_H}{T_L}\right)$

D. $1-\left(\frac{T_L}{T_H}\right)$

25. M04 TZ1 H1:23

A string is stretched between two fixed points. The string is plucked at its centre and is seen to vibrate with frequency f as shown below.



Which **one** of the following expressions gives the frequencies of other possible modes of vibration that have an antinode at the centre? The number n in each expression is an integer.

A. nf

B. $(2n-1)f$

C. $(n-1)f$

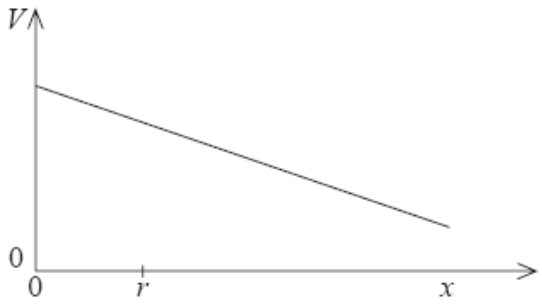
D. $(n+1)f$

26. M04 TZ1 H1:31

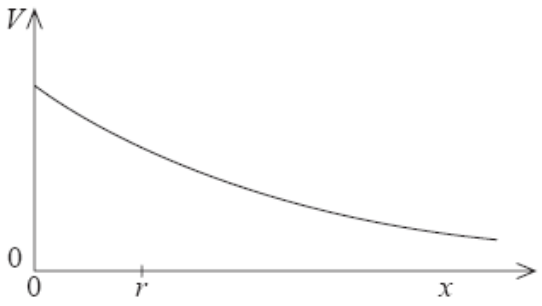
An isolated *conducting* sphere of radius r is positively charged.

Which **one** of the following graphs best shows the variation with distance x from the centre of the sphere of the electric potential V?

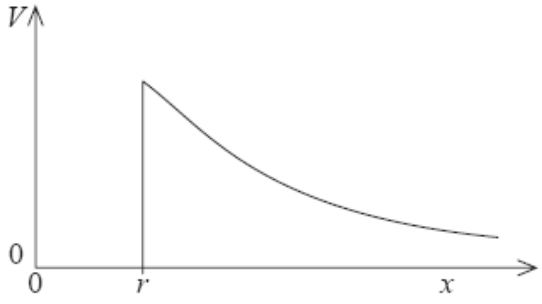
A.



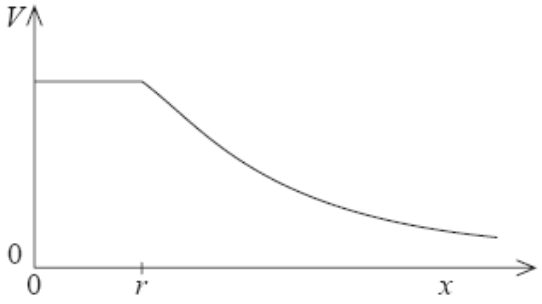
B.



C.



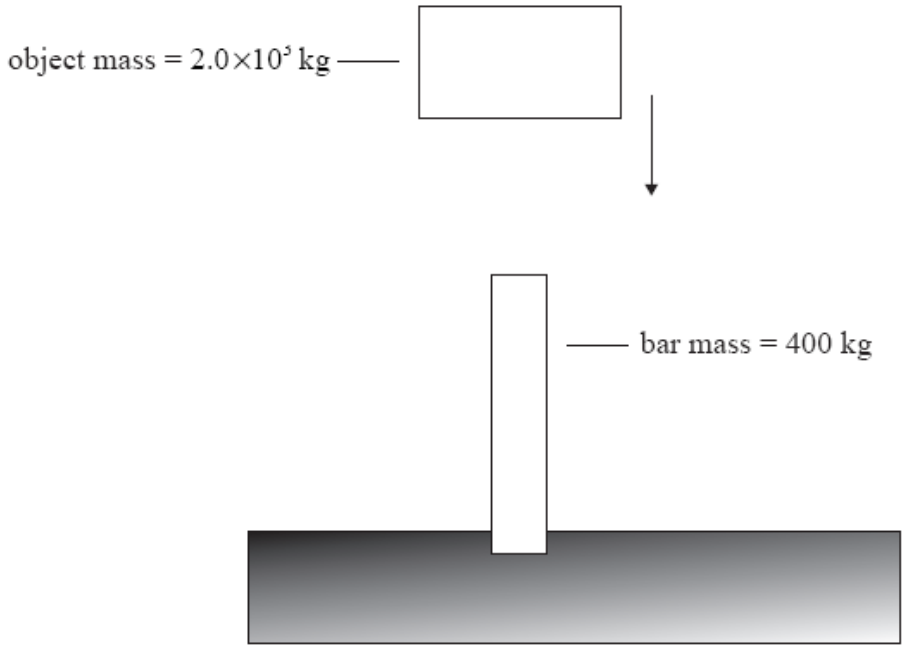
D.



27. M04 TZ1 H2:B4p1

Part 1 The metal bar

Large metal bars can be driven into the ground using a heavy falling object.



In the situation shown, the object has a mass 2.0×10^3 kg and the metal bar has a mass of 400 kg.

The object strikes the bar at a speed of $6.0\,m\,s^{-1}$. It comes to rest on the bar without bouncing. As a result of the collision, the bar is driven into the ground to a depth of 0.75 m.

(a) Determine the speed of the bar immediately after the object strikes it. *[4]*

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(b) Determine the average frictional force exerted by the ground on the bar. *[3]*

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(c) The object is raised by a diesel engine that has a useful power output of 7.2 kW.

In order that the falling object strikes the bar at a speed of $6.0\,\mathrm{m\,s^{-1}}$, it must be raised to a certain height above the bar. Assuming that there are no energy losses due to friction, calculate how long it takes the engine to raise the object to this height. *[4]*

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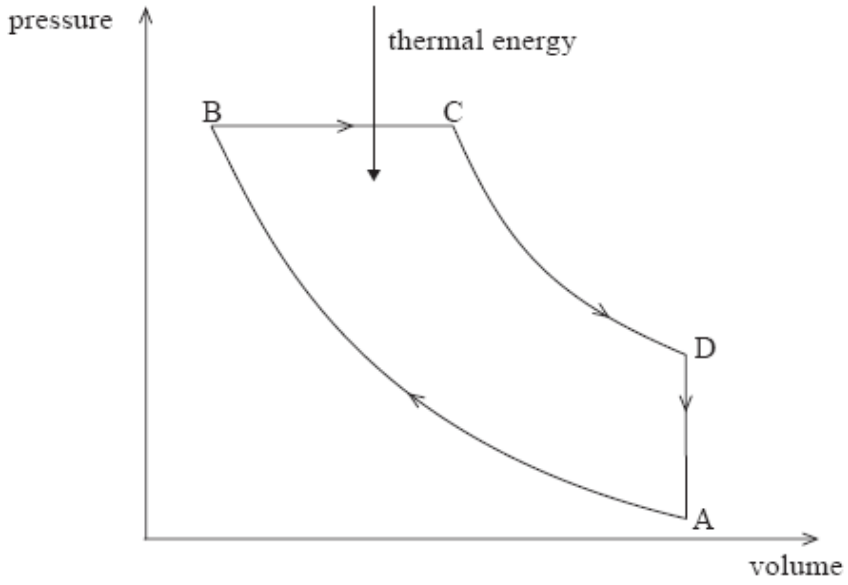
The diagram below shows the relation between the pressure and the volume of the air in the diesel engine for one cycle of operation of the engine. During the cycle there are two adiabatic processes, an isochoric process and an isobaric process.



(d) Explain what is meant by

(i) an adiabatic process. *[2]*

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(ii) an isochoric process. *[1]*

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(iii) an isobaric process. *[1]*

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(e) Identify, from the diagram, the following processes.

(i) Adiabatic processes *[1]*

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(ii) Isochoric process *[1]*

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(iii) Isobaric process *[1]*

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During the process B → C thermal energy is absorbed.

The diesel engine has a total power output of 8.4 kW and an efficiency of 40 %. The cycle of operation is repeated 40 times every second.

(f) State what quantity is represented on the diagram by the area ABCD. *[1]*

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(g) Determine the value of the quantity that is represented by the area ABCD. *[1]*

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(h) Determine the thermal energy absorbed during the process B → C. *[2]*

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