HALF YEARLY EXAMINATION 2001

YEAR 12

PHYSICS

TIME ALLOWED: 2½ hours

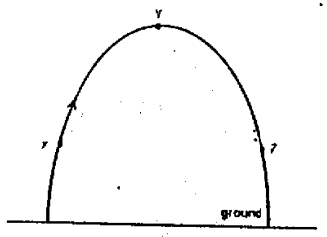
INSTRUCTIONS TO STUDENTS

This examination paper consists of two sections:
SECTION 1 – Space (47 marks)
SECTION 2 – Motors and Generators (33 marks)

Students are advised to show all working.
Answers must be written on the Answer booklet provided.
A data sheet and formulae sheet are provided.

SECTION 1 – SPACE
PART A – Multiple Choice

1 An object is projected upwards from the ground and follows a path represented in the diagram below



It is true to say that the magnitude of the object's acceleration

A. at point X is equal to that at point Y
B. at point X is less than at point Z
C. at point Y is less than at point X
D. at point Y is less than at point Z

2. A set of bathroom scales is placed on the floor of a lift. A person of mass 70.0 kg stands on the scales. The scales are calibrated in newtons. The lift is moving upwards with a constant acceleration of 4.0 ms^{-2}.

Take g, the acceleration due to gravity, to be 9.8 ms^{-2}.
What is the reading on the scales while the lift is in motion?

A. 280 N
B. 406 N
C. 686 N
D. 966 N

3 The artificial satellite Telstar is in an equatorial orbit and makes one orbit per day. The statement which is not correct is that Telstar

A. appears motionless when viewed from earth
B. appears to move in a circle when viewed from a non-rotating frame in space on the prolongation of the axis of the earth
C. is accelerating towards earth
D. is kept up by centrifugal force

PART B

3 Consider the following data (2 marks)

Planet	Average distance from Sun, R(AU)	Period T (days)	T^2 / R^3 (day^2 (AU)$^{-3}$)
Mercury	0.389	87.77	1.31×10^5
Venus	0.723	228.1	1.32×10^5
Earth	1.000	365	1.37×10^5
Mars	1.524	689.88	1.34×10^5
Saturn	9.510	10759.2	1.35×10^5

A student suggested that the value of T^2 / R^3 for Halley's comet as it orbits the sun should be close to 1.3×10^5 day^2 (AU)$^{-3}$. Is the suggestion justified? Give a reason for your answer.

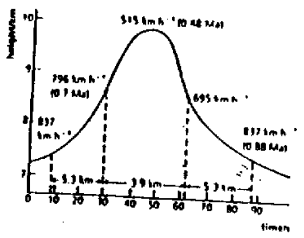
(3 marks)

A work experience student from the Meriden Physics class is at NASA and asked to calculate the energy required by a space craft of 2000 kg to overcome the Earth's gravitational field and reach a distance of 10 000 km from the Earth's surface.
The radius of Earth = 6380 km
The mass of the Earth = 5.9783×10^{24} kg
Universal constant of gravitation = 6.67×10^{-11} N.m^2 kg^{-2}

a) Calculate the minimum energy required for this space journey
b) The student is then asked to determine the energy required for a journey to the moon. Is it valid to repeat the calculation in part a) using the distance to the moon? Justify your answer.
c) The acceleration due to gravity on Uranus is 9.2 ms^{-2} and on Neptune, the acceleration due to gravity is 10.4 ms^{-2}. The planets have the same radius. Suggest a reason for the difference in acceleration due to gravity.

(3 marks)

a) The sketch below shows the data for the approximate parabolic path taken by a KC-135 (Boeing 707) plane while allowing astronauts to experience weightlessness.

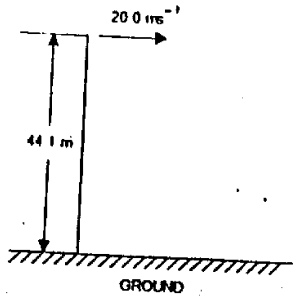


Suggest the time period during which weightlessness is experienced.

b) Describe 2 difficulties associated with effective and reliable communications between satellites and Earth.

7 (5 marks)

An object of mass 2.0 kg is projected horizontally with a speed of 20.0 ms^{-1} from the top of a cliff. The height of the cliff is 44.1 m.



Take g, the acceleration due to gravity, to be 9.8 ms^{-2}.

a) How long was the object in flight?
b) How far horizontally from the base of the cliff does the object land?
c) Calculate the velocity of the mass as it lands, stating magnitude and direction

8 (5 marks)

a) What distinguishes an inertial reference frame from a non-inertial reference frame? Suggest one experiment you could use to test whether or not you are in a non-inertial reference frame.
b) Two observers, A and B, are travelling through space. B is receding from A with a speed of 0.8c. A transmits a pulse of light and sees it travel towards B with a speed of c. With what speed does B see the light pulse pass?
c) A spaceship flies past earth with a speed of 0.99c (about 2.97 x 10^8 ms^{-1}). On the spaceship a high-intensity signal light (perhaps a pulsed laser) blinks on and off, each pulse lasting 2 x 10^{-6} s as measured on the spaceship. What is the duration of each light pulse, as measured on earth?

9. (6 marks)

a) Einstein used "thought" experiments in his work.

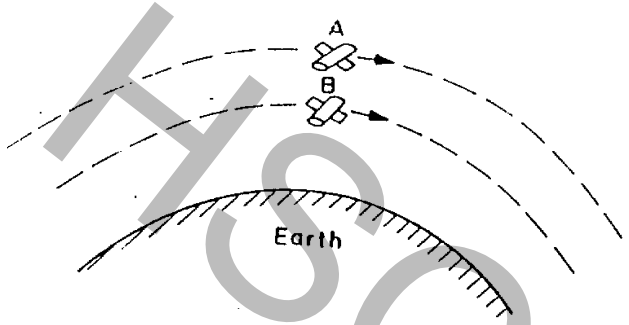
i) Describe and interpret one such thought experiment involving trains or mirrors
ii) What was the purpose of these thought experiments?

b) Einstein's theory on relativity is today an accepted part of Physics.

i) Describe one piece of modern evidence which supports his theory.
ii) Discuss the relationship between theory and supporting evidence using Einstein's work as an example.

10. (3 marks)

a) The diagram below shows two satellites, A and B, in different orbits about the Earth



Transmissions from each satellite are received simultaneously by an observer at a ground station. Is the observer justified in saying that the two satellites began transmitting simultaneously? Explain your answer.

b) The findings of the Michelson-Morley experiment have been called "the greatest of all negative results in the history of science".

i) What was 'negative' about the results?
ii) What is the scientific significance of these negative results?

(17 marks)

A group of students is using a rubber stopper on a string to demonstrate that the closer a satellite is to its parent body, the faster it moves to maintain a stable orbit. The mass is attached to metal washers which hang vertically as the rubber stopper moves in a horizontal circle.

a) Draw a diagram of the apparatus, showing the string, rubber stopper, the metal washers and the path of the moving stopper. (1 mark)

b) Which part of the apparatus behaves as the satellite? Which part of the apparatus behaves as the parent body? (2 marks)

c) Explain how the students should measure the movement of the stopper. (2 marks)

d) The teacher states that the number of washers should be changed as the radius of the circular motion of the stopper is altered. Justify her statement. (1 mark)

e) What is the independent variable in this experiment? What is the dependent variable in this experiment? (2 marks)

f) Draw a suitable result table for the results of the experiment. (2 marks)

g) Suggest sources of error and if possible, how these could be reduced. (4 marks)

h) The teacher suggests that a graph is drawn to examine the results. (3 marks)
i) What variables would be plotted on the axes?
ii) How would you expect these variables to relate?
iii) Why do physicists draw graphs rather than examine trends in tables?

SECTION 2 MOTORS AND GENERATORS

PART A – Multiple Choice

1 Two long, parallel wires carry currents I_1 and I_2 and are separated by a distance of 2cm. The force acting on each metre of one wire is 0.3 newtons. If both currents are doubled and the separation of the wires is increased to 4 cm, the force acting on each metre of wire will be in newtons

A 0.3
B 0.6
C 0.9
D 1.8

2. AC electricity transmitted at 33 000 V is required for use at 240 V. What would be the primary/secondary turns ratio for a transformer which would do this?

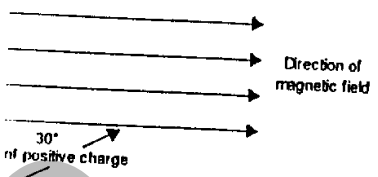
A. $\frac{33000}{240}$

B $\frac{240}{33000}$

C. 240 x 33 000

D $\frac{33000}{1}$

3 The diagram below shows a positive charge entering a magnetic field at an angle of 30° to the field direction.



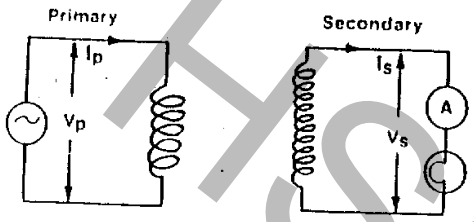
What is the direction of the magnetic force on this charge?

A. out of the page
B. into the page
C. to the left of the page
D. to the right of the page

4. Two wires PQ and RS are parallel. PQ is longer, and carries a current twice that in RS. RS exerts a force F on PQ. The force PQ exerts on RS will be

A. somewhat greater than F
B. equal to F
C. less than F
D. more than 2F

5 An ideal voltage transformer has more turns of wire in the secondary coil than the primary coil

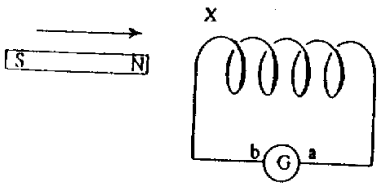


The voltage across the primary coil is V_p
The current flowing in the primary coil is I_p
The voltage across the secondary coil is V_s
The current flowing in the secondary coil is I_s

Which of the following statements is correct?

A	I_p	<	I_s	;	V_p	<	V_s
B	I_p	>	I_s	;	V_p	<	V_s
C	I_p	<	I_s	;	V_p	>	V_s
D	I_p	>	I_s	;	V_p	>	V_s

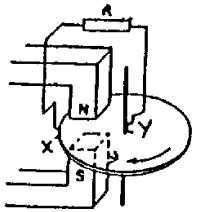
The diagram shows the north pole of a magnet being moved into a coil of wire which is connected to a galvanometer, G.



Which row of the following table gives correct information about the direction of the current through G and polarity of the coil?

	Direction of conventional current through G	Polarity of end X of coil
A	a → b	south
B	a → b	north
C	b → a	south
D	b → a	north

7 A metal disc rotates at constant speed between the poles of a magnet in the direction shown the diagram below. Contacts X and Y just touch the edge of the metal disc and axle



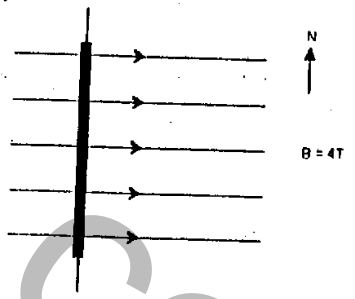
Which statement about the current *through the resistor*, R, is correct?

A a current flows through R from X to Y
B a current flows through R from Y to X
C no current flows through R because the emf in the disc is opposed by the back emf
D no current flows through R because the emf induced in one side of the disc is opposed by the emf induced in the other side.

PART B

8 (2 marks)

A rod weighing 2 newtons and 10cm long is suspended horizontally at right angles to a horizontal magnetic field of intensity 4 teslas.



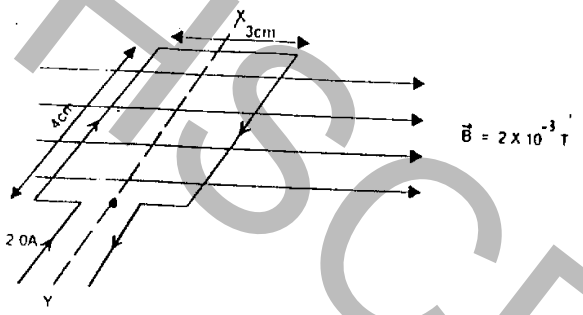
Determine the magnitude and direction of the current needed through the rod in order to just lift it off its support.

9 (3 marks)

Soft iron cores are an important part of practical transformers but result in energy loss due to heating

a) Name the cause of this heating effort.
b) How is it overcome?
c) Small appliances around the home such as kitchen scales may be operated using batteries or a transformer connected to mains power. Name the type of transformer required

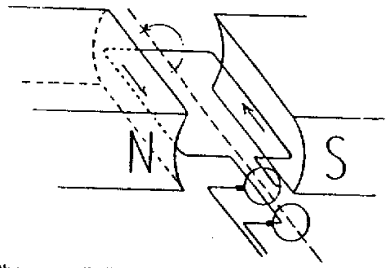
The diagram below represents a rectangular coil with its plane parallel to a uniform magnetic field of 2×10^{-3} T. The coil consists of 300 turns of wire and is carrying a current of 2A. It is free to rotate about the axis XY.



a) Calculate the magnitude of the torque on the coil in the position shown
b) Through what angle would the coil have to rotate, from the position shown, to first reach the position of zero torque?
c) Discuss the importance of the commutator to allow the coil above to function as a motor
d) Suggest 2 ways in which the magnetic field can be produced

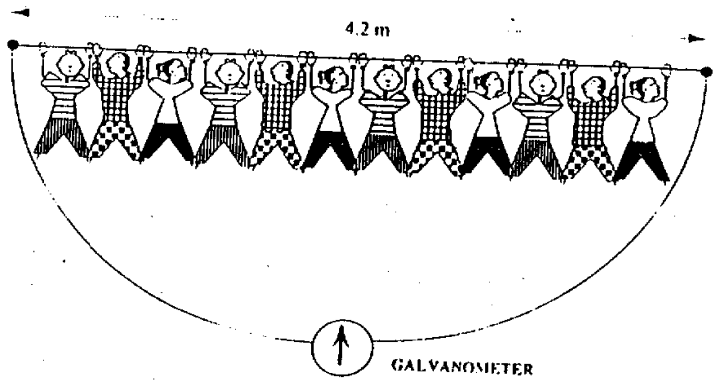
(8 marks)

As shown in the diagram below, an electric generator, in its simplest form, needs a rotating rectangular coil of conducting wire and one or more magnets.



a) Describe how the magnetic flux through the coil changes as the coil rotates through one revolution. (2 marks)
b) Explain the generation of an emf in the coil. (2 marks)
c) What type of current is generated by the apparatus shown? (1 mark)
d) Analyse the effects of the development of AC and DC generators on society and the environment.

A Year 12 Physics class performs an experiment on electromagnetic induction. The pupils stand in a straight line in the playground with a copper wire of length 4.2m, which is held above their heads in an East/West direction, as shown in the diagram



The wire is attached by connecting wires to a galvanometer. At a signal from the teacher the pupils lower the wire, then raise it again to its original position.

a) Describe the movement of the galvanometer needle as the wire is raised and lowered (2 marks)
b) i) Explain the principle of an AC induction motor. (2 marks)
ii) Discuss why the majority of motors are AC induction motors (2 marks)
c) Explain how the principle of induction is
- used in cooktops
OR
- used in electromagnetic braking (2 marks)

PHYSICS DATA SHEET

Numerical values of several constants

Charge on the electron, q_e	$-1{\cdot}602 \times 10^{-19}$ C
Mass of electron, m_e	$9{\cdot}109 \times 10^{-31}$ kg
Mass of neutron, m_n	$1{\cdot}675 \times 10^{-27}$ kg
Mass of proton, m_p	$1{\cdot}673 \times 10^{-27}$ kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	$9{\cdot}80$ m s^{-2}
Speed of light, c	$3{\cdot}00 \times 10^{8}$ m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	$2{\cdot}0 \times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	$6{\cdot}67 \times 10^{-11}$ N m^2 kg^{-2}
Mass of Earth	$6{\cdot}0 \times 10^{24}$ kg
Planck's constant, h	$6{\cdot}626 \times 10^{-34}$ J s
Rydberg's constant, R_H	$1{\cdot}097 \times 10^{7}$ m^{-1}
Atomic mass unit, u	$1{\cdot}661 \times 10^{-27}$ kg
	$931{\cdot}5$ MeV/c^2
1 eV	$1{\cdot}602 \times 10^{-19}$ J
Density of water, ρ	$1{\cdot}00 \times 10^{3}$ kg m^{-3}
Specific heat capacity of water	$4{\cdot}18 \times 10^{3}$ J kg^{-1} K^{-1}

PERIODIC TABLE OF THE ELEMENTS

KEY: Atomic Number 79; Symbol of element Au; Atomic Weight 197.0; Name of element Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.