H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET A

PAPER 2

Answer

Compiled by

THE PHYSICS CAFE

1 (a) The vertical component of the tension is equal and opposite to the weight of the load.

(b) (In order that the crane does not topple, the system must be in rotational equilibrium.)

Weight of M creates an anticlockwise moment about the axis through the tower, which balances the clockwise moment due to the vertical component of the tension force

$Mg \times d = T\cos\theta \times (15)$ where d is the perpendicular distance between M and the tower

(The horizontal components of T and force at mass M passes through the pivot, hence they do not give rise to any moments about this pivot)

Since the vertical component of the tension is always equal to the weight of the load (which is constant), the moment of the tension force about the tower is constant.
Hence for same M, distance d (and therefore position of M) need not be altered

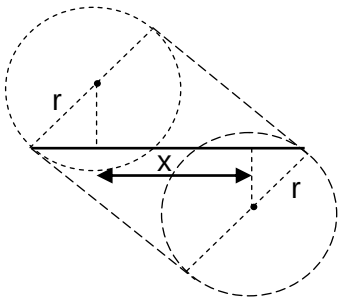
(c) Work done on the load is zero.
(Since we neglect air resistance,) Resultant force (centripetal force) is always perpendicular to the direction of motion, hence work done is zero
Reason incorrect – no marks

2 (a) diameter of ball = $0.79/\pi = 0.25$ m
diameter of rim = 0.45 m
from fig 2.2 , $\theta = \sin^{-1}(0.25/0.45) = 33.7°$

(b) 1 horizontal speed is constant from point of projection to going through the basket.

Hence horizontal speed = $8.0 \cos 52.3° = 4.9$ m s^{-1}

2



Select corresponding points on the balls, e.g. centre of mass, to represent the movement
$x = 0.45 – (2 \times r \sin 33.7°) = 0.45 – (2 \times 0.125 \sin 33.7°) = 0.31$ m

(c) time = horizontal distance / horizontal speed = 0.31 / 4.9 = 0.063 s

3. (a) One tesla is defined as the flux density of a uniform magnetic field when the force on a conductor 1 metre long, placed perpendicular to the field and carrying a current of 1 ampere, is 1 newton.

(b) (i) The magnetic force is always perpendicular to displacement or tangential velocity or the direction of motion of the electron, **and**
the force does not change the magnitude of the velocity (speed) but its direction (**Or** the force is centripetal / acts towards centre of curvature)

(ii) magnetic force = centripetal force

$$Bev = \frac{mv^2}{r}$$

i.e. $e/m = v/Br = \frac{3.2\text{x}10^7}{(7.3\text{x}10^{-3})(25\text{x}10^{-3})}$

$$= 1.75\text{x}10^{11} = 1.8\text{x}10^{11}\,\text{C kg}^{-1}$$

(iii) $Bev = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Be}$ Hence radius is halved

4 (a) (i) e.m.f. E of the battery is 12 V.
reason – when I = 0 the terminal voltage, V is equal to the e.m.f.

(ii) $E = Ir + I\,\text{R} = Ir + V$ $\quad -①$

$$I = \frac{(E-V)}{r} = (-\frac{1}{r})V + \frac{E}{r}$$

Hence r = – 1/gradient = 2.0 Ω **OR** $\frac{E}{r}$ = y-intercept, r = $\frac{12}{6}$ = 2.0 Ω

(b) From ① , $\frac{V}{I} = \frac{E}{I} - r$

$\Rightarrow \quad R = \frac{12}{I} - 2$

(i) In series, R = 10.0 Ω , I = 1.0 A; S – (10,1)

(ii) In parallel, R = 0.968 Ω , I = 4.04 A; P – (3.91,4.04)

(c) ammeter series with R

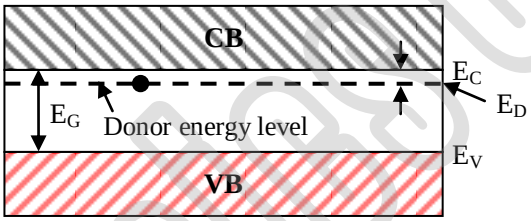
voltmeter parallel with R

5 (a) *population inversion* – A condition in which a higher energy state (in an atomic system) has much more electrons/atoms than a lower energy state of the same system.

metastable state – It is an energy state where atoms stay much longer (10^{-3} s) before transiting to lower energy states as compared with other excited states (10^{-7} s). (**Or** It is an excited state of an atom that has a longer lifetime (10^{-3} s) than the ordinary excited states (10^{-7} s) but a shorter lifetime than the ground state).

stimulated emission – A photon is emitted when an excited atom in a higher energy state, E_2 is de-excited to a lower energy state, E_1 when an incoming photon of energy ($E_2 - E_1$) is incident onto the excited atom. Two photons of energy ($E_2 - E_1$) are now available to trigger off further emissions from other excited atoms in the E_2 state. (**Or** Photons incident on a matter trigger excited atoms to transit from a higher energy level to a lower one and emit photons. The incident photons and their emitted counterparts have the same frequency and phase; this frequency corresponds to the energy difference between the two energy levels).

(b)



In an intrinsic semiconductor, most of the electrons are in the valence band (VB) and very few in the conduction band (CB). VB is separated from CB by an energy gap, E_G of about 1eV. After doping with n-type impurity, an allowable energy level E_D is introduced. Electrons in this level need less energy (0.01 eV) to move to CB. Hence conductivity increases.

6 (a) Gamma photons can be detected outside body. Gamma photons are less ionizing than α and β particles thus cause less damage to living tissue in the body.

(b)(i) $A = A_o e^{-\lambda t}$

$$400 = 1.2\times10^4 e^{-\frac{\ln 2}{15}t}$$

$$\ln\frac{400}{1.2\times10^4} = -\frac{\ln 2}{15}t$$

$$t = 73.6\text{hrs}$$

(ii) $A = \lambda N$

$$400 = \lambda\frac{m}{24\times10^{-3}}(6.02\times10^{23})$$

$$400 = \frac{\ln 2}{15\times3600}\frac{m}{24\times10^{-3}}(6.02\times10^{23})$$

$$m = 1.24\times10^{-18}\text{kg}$$

(c) The background count rate should be low to reduce the percentage error in measurement of the activity of Sodium-24

7. (a) • Reduced drag / as fewer collisions between shuttle and particles in atmosphere
• Less fuel/energy needed / as less air resistance/drag
• Greater acceleration/velocity / as less air resistance/drag

Suggestion/explanation pairs needed for two marks. Do not accept 'friction'.

(b) (i) Uniform gradient ('straight line' acceptable)

(ii) g = gradient of V_g vs h graph

$$= \frac{(-61.64-(-62.40))\text{x}10^6}{(88-10)\text{x}10^3} = 9.7\ N\,kg^{-1}$$

(c) Energy required = mg(Δh) = 3800 x 9.7 x 90 x 10^3 = 3.32 x 10^9 J
OR
Energy required= m(ΔV_g) = 3800 x (-61.52-(-62.40)) x 10^6 = 3.34 x 10^9 J

(d) Net force = vertical thrust – weight of the shuttle
= 74 x 10^3 - (9.7 x 3800) = 37140 N
Net acceleration a = Net force / mass = 37140/3800 = 9.8 m s^{-2}

(e) (i) p.e. gain = k.e. loss, and lower k.e. $\Rightarrow$ lower speed
(OR Gravitational force acting on space shuttle opposes motion.)

(ii) Low atmosphere
• gravitational force acting on both passengers and shuttle
• Passengers and shuttle falling freely with the same acceleration
• No contact force between shuttle and passengers

In thicker atmosphere
• air resistance acting on shuttle causes deceleration
• air resistance does not act on the passengers directly.
• shuttle and passengers experience different accelerations - the net acceleration of shuttle smaller than acceleration of passengers
• passengers coming into contact with body of shuttle – resulting in contact forces between passengers and shuttle. Hence weightlessness disappears

(f) gravitational force = centripetal force

$$\text{i.e.}\quad \frac{GMm}{r^2} = mr\omega^2$$

$$\omega = \sqrt{\frac{GM}{r^3}} = \sqrt{\frac{g(R_E)^2}{r^3}}$$

$$= \sqrt{\frac{(9.7)(6.4\text{x}10^6)^2}{(6.4\text{x}10^6+100\text{x}10^3)^3}} = 1.20\text{x}10^{-3}\ rad\,s^{-1}$$