JC2 (05/06) Physics Common Test 2006
Suggested Answers:

Paper 1

1	D	16.	A
2	A	17.	B
3	D	18	A
4	B	19	C
5	C	20	B
6	B	21	D
7	C	22	D
8	A	23	A
9	A	24	B
10	C	25	C
11	A	26	D
12	B	27	C
13	C	28	B
14	D	29	D
15.	C	30	C

Paper 2

1.

(a) $v = \dfrac{pr^2}{8\eta L} \Rightarrow \eta = \dfrac{pr^2}{8vL} \Rightarrow$ unit of η = $\dfrac{(\text{kg m}^{-1}\ \text{s}^{-2})(\text{m})^2}{(\text{m s}^{-1})(\text{m})}$ = kg m^{-1} s^{-1}

(b) η = $\dfrac{(6.5\times10^3)(0.051)^2}{8(1.82)(980)}$ = 1.18 × 10^{-3} kg m^{-1} s^{-1}

$\dfrac{\Delta\eta}{\eta} = \dfrac{\Delta p}{p} + 2\dfrac{\Delta r}{r} + \dfrac{\Delta v}{v} + \dfrac{\Delta L}{L} = 0.01 + 2\dfrac{0.001}{0.051} + \dfrac{0.04}{1.82} + \dfrac{1}{980} = 0.0722$

$\Rightarrow$ Δη = 0.0722 × 1.18 × 10^{-3} = 8.56 × 10^{-5} = 9 × 10^{-5} kg m^{-1} s^{-1} (1 s.f.)

∴ η = (1.18 ± 0.09) × 10^{-3} kg m^{-1} s^{-1}

(c) speed contributes $\dfrac{\Delta v}{v}$ = 2.2%

pressure contributes $\dfrac{\Delta p}{p}$ = 1%

length contributes $\dfrac{\Delta L}{L}$ = 0.1%

radius contributes $2\dfrac{\Delta r}{r}$ = 3.9%

at 3.9%, radius contributes the the greatest error to η

Feedback on Question 1

1. For 1(b),
   - ✓ A large number of students did not physically show $\dfrac{\Delta\eta}{\eta} = \dfrac{\Delta p}{p} + 2\dfrac{\Delta r}{r} + \dfrac{\Delta v}{v} + \dfrac{\Delta L}{L}$.
   - ✓ Some students miss out η.
   - ✓ Students did not express $\dfrac{\Delta\rho}{\rho}$ = 0.01. Instead most substitute $\dfrac{\Delta\rho}{\rho}$ as $\dfrac{0.01}{6.5 \text{ x } 10^3}$ or $\dfrac{1}{6.5 \text{ x } 10^3}$.
   - ✓ Some students did not express Δη as 1 s.f.
   - ✓ Most students do not know how to express η = (1.18 ± 0.09) x 10^{-3} kg m^{-1} s^{-1}. Unit is left out as well.
   - ✓ Students are not careful on their s.f.

2.

(a)

$a = 5.0/(4.0 - 6.5) = -2.0\ m\ s^{-2}$

$v_0 = at = -2.0 \times (8.0 - 6.5)$

$\quad = -3.0\ m\ s^{-1}$

or

$5.0/v_0 = (4.0 - 6.5)/(8.0 - 6.5)$

$v_0 = -3.0\ m\ s^{-1}$

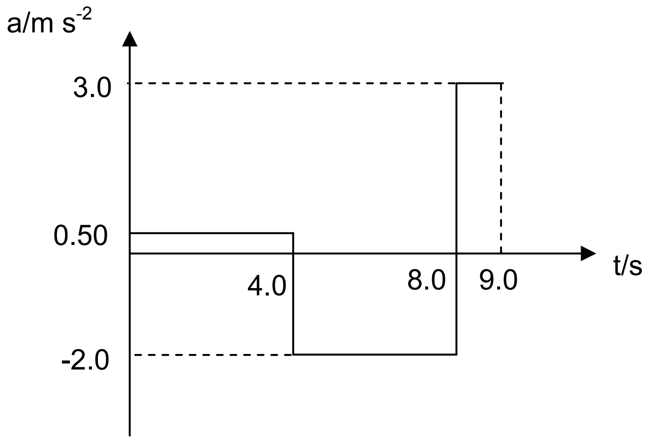
(b)

Maximum displacement occurs at t = 6.5 s.

Maximum displacement = ½(3.0 + 5.0) x 4.0 + ½ x 5.0 x(6.5 – 4.0)

= 22 m

(c)



Feedback on Question 2

1. Generally, this is a simple question. Quite a number of students are scoring at least 8 marks for this question.
2. Students are not careful on their s.f.
3. For (a),
    - ✓ Poor working are demonstrated by some students.
    - ✓ Some students did not demonstrate that the gradient of the v-t graph is acceleration.
4. For (b), generally quite a number of students did not know how to read the graph to find the maximum displacement.
5. For (c),
    - ✓ Labelling on the axes are often missing, especially the vertical axis.
    - ✓ The graph is not drawn to proportion. For e.g., the vertical height of $3.0\ m\ s^{-2}$ is as tall as $-2.0\ m\ s^{-2}$.

3(a) At equilibrium, $T = W_B$

$= 25.0 \times 9.81$

$= 245$ N

3(b) <u>Method 1:</u>

(i) & (ii) Block B: $m_Bg - T' = m_Ba$

Block A: $T' = m_Aa$

Substituting: $m_Bg - m_Aa = m_Ba$

$(m_A + m_B)\, a = m_Bg$

$(32 + 25)\, a = 25 \times 9.81$

$a = 4.30 \text{ m s}^{-2}$

$T' = m_Aa$

$= 32 \times 4.30 = 138$ N

<u>Method 2:</u>

(i) Apply "$F = ma$" to A and B as a whole:

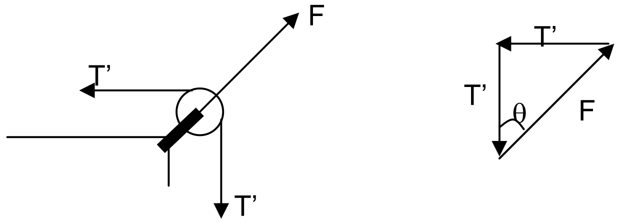
$m_Ag = (m_A + m_B)\, a$

$\Rightarrow a = (32.0 \times 9.81) / (32.0 + 25.0) = 4.30 \text{ m s}^{-2}$

(ii) Apply "$F = ma$" to A only:

$T = m_Aa = 32.0 \times 4.30 = 138$ N

(iii)



$F = \sqrt{T'^2 + T'^2} = \sqrt{138^2 + 138^2} = 195 N$

$\sin\theta = 1$ $\theta = 45^\circ$

Feedback on Question 3

1. For (a), some students use g = 10 m s^{-2} which will be penalised
2. Some students did not realise that the tension is the same throughout the whole rope (note: tension is the same because it is a single rope and the pulley is smooth)
3. For (b), many students did not apply "$F = ma$" correctly, either using the wrong m or using the wrong F; many did not realise that the tension in the rope no longer has the same value as in (a).
4. For (c), many students did not draw the free-body diagram which is important for solving forces problems and many students got the direction of tension wrong.

4 (a) Version 1:

The gravitational potential at infinity is defined as zero

The external force required to bring a mass from infinity to any point is in the opposite direction to the displacement of the mass. OR

As such, work done against gravitational attraction is negative.

Version 2:

The gravitational potential at a point is the work done per unit mass by an external agent in bringing a small mass from infinity to that point. As gravitational force is attractive nature, the force acted by the external agent is opposite in direction to the displacement of the small mass resulting in negative work and hence negative potential.

4bi) Change in gravitational potential, $\Delta\phi = \phi_{500km\ above} - \phi_{surface}$

$$= -GM_E\left(\frac{1}{R_E + 500000} - \frac{1}{R_E}\right)$$

$$= 4.53 \times 10^6 \text{ J kg}^{-1}$$

Change in gravitational potential energy, $\Delta U = m\Delta\phi$

$$= 750 \times 4.53 \times 10^6$$

$$= 3.40 \times 10^9 \text{ J}$$

4bii) using $\frac{mv^2}{r} = \frac{GMm}{r^2}$,

$$v = \sqrt{\frac{GM}{r}}$$

$$= \sqrt{\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{6.4 \times 10^6 + 500000}}$$

$$= 7620 \text{ ms}^{-1}$$

4biii) Period of the orbit $= \frac{2\pi r}{v}$

$$= \frac{2\pi \times 6.9 \times 10^6}{7620}$$

$$= 5690 \text{ s}$$

Number of orbits in a day $= \frac{24 \times 60 \times 60}{5690}$

$$= 15.1$$

Feedback on Question 4

1. For (b)(i), many students did not include the minus sign in calculating the potential; some students only calculated the potential and not the required change in potential.

5a)

$$\Delta u = q + w$$

Δu : increase in internal energy
q : heat absorbed by the system
w : work done on the system

5b

(i) Consider path **abc** :

$$\Delta u_{ac} = q_{ac} + w_{ac}$$
$$= 80 + (-30)$$
$$= 50 \text{ J}$$

(ii) Since Δu is the same for path **abc** and **adc**,

Consider path **adc** now :

$$\Delta u_{ac} = q_{adc} + w_{adc}$$
$$50 = q_{adb} + (-10)$$
$$q_{adb} = 60 \text{ J}$$

Consider path **ad** :

$$\Delta u_{ad} = q_{ad} + w_{ad}$$
$$40 = q_{ad} + (-10)$$
$$q_{ad} = 50 \text{ J}$$

(iii)

Consider path **ca** :

$$\Delta u_{ca} = -50 \text{ J}$$
$$\Delta u_{ca} = q_{ca} + w_{ca}$$
$$-50 = q_{ca} + 20$$
$$q_{ca} = -70 \text{ J}$$

The system gives out heat.

Feedback on Question 5

1.

6.(a) The principle of superposition states that when **two waves of the same kind** meet at a point, the **resultant displacement is the vector sum** of the individual displacements at that point.

(b)(i) $I \propto A^2 \rightarrow I = kA^2$

$2I = 2\,kA^2 = k\left(\sqrt{2}A\right)^2$

Maximum resultant amplitude:

$A_{max} = A + \sqrt{2}\,A$

Maximum intensity:

$I_{max} = k[(\sqrt{2} + 1)A]^2 = 5.83\,kA^2 = 5.83\,I$

(b)(ii) Path difference

= 14.02 – 13.72

= 0.30 m

= 2½ λ

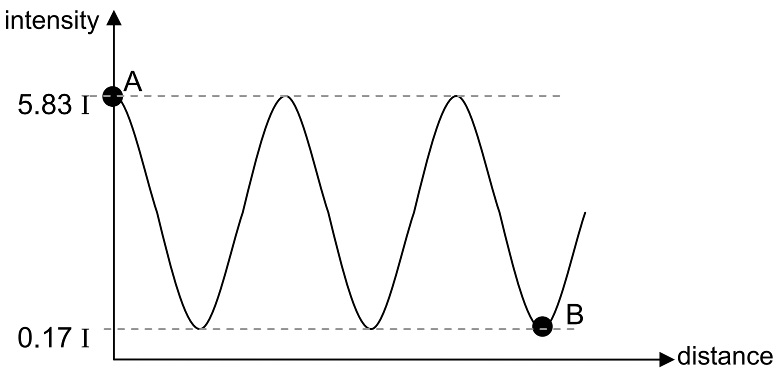
Since the two sources are in phase, therefore destructive interference occurs at B and amplitude is minimum.

Minimum resultant amplitude:

$A_{min} = \sqrt{2}\,A - A$

$I_{min} = k[(\sqrt{2} - 1)A]^2 = 0.17\,kA^2 = 0.17\,I$

(b)(iii)



Feedback on Question 6

1. (a) Resultant amplitude is the vector sum of individual amplitudes. – wrong!
2. (b)(i) 2I + I = 3I
3. (b)(ii) 2I – I = I or simply minimum intensity = 0
4. (b)(iii) Point B should be 2.5 wavelengths away from point A

7(a)

Description / Location of light	Voltage / V	Power / W	Resistance of each bulb / Ω
Head	12	60	2.40
Tail (Number plate)	12	5	28.8
Side	12	5	28.8
Stop	12	21	6.86
Reversing	12	21	6.86

(a) p $= V^2/R$
$=(12^2)/2.4$
= 60 W

(b) This is to ensure the bulbs can be switched on and off individually.

(c) When they are on at the same time, it is equivalent to having 3 resistors connected in parallel.

Formula for 3 resistors in parallel

The combined resistance = $(1/28.8 + 1/6.86 + 1/6.86)^{-1}$ Ω
= 4.65 Ω

(d) The total resistance will be 2.0 + 4.65 = 6.65 Ω
Therefore the current drawn from the battery = 12/6.65 =1.80 A.

This current will be shared by the two stop lights and one tail light

Potential drop across the internal resistance = Ir = 1.80 (2.0) = 3.6 V

Pd across the tail and stop lights respectively = 12-3.6 V = 8.4 V

I across tail light = 8.4/28.8 A = 0.29 A

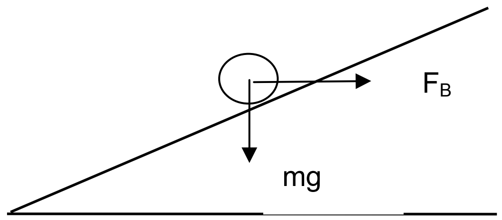
I across stop light = 8.4/6.86 = 1.22

Feedback on Question 7

1.

8a The magnetic flux density, B at a point is defined as the **force per unit length per unit current** acting on a conductor placed at **right angle** to the B-field.

8b. i.



ii. Direction of the magnetic field B acting on the brass rod is **upwards**

iii. Magnetic force along the plane = $F_B \cos 20^0$

= $BIL \cos 20^o$

= 0.940 B

ii. As rod is kept stationary,

$(F_{net})_{along\ the\ plane} = 0$

$F_B \cos 20^0 - mg \sin 20^o = 0$

$B\ I\ L \cos 20^o = mg \sin 20^o$

$B \times 5 \times 20 \times 10^{-2} \cos 20^o = 0.5 \times 9.81 \sin 20^0$

B = 1.79 T

Feedback on Question 8

1. Can't remember definition.
2. Problem drawing a free body diagram
3. Resolution of forces along the plane

9 (a) (i) deflected upwards
in a parabolic path

(ii) deflected out of the paper
in a circular path

(b) (i) moves vertically downwards
with decreasing speed

(ii) moves vertically downwards at constant speed

(c) into the paper

$Bqv = qE$ (or variation $v = E/B$ or substitution)

obtain $B = 4.0 \times 10^{-4}$ T

Feedback on Question 9

1. For (a), Students mix up between the path taken by a charged particle in magnetic field and electric field.
2. For (aii), students did not reverse the direction of the current for electron when applying Fleming's left hand rule.
3. For (b), students state the effect of gravity on the charged particle which is to be ignored as stated in the question.
4. For c, units for B field stated wrongly e.g Wb

10. An experiment on the photoelectric effect was carried out using the following set-up.

(a) Instantaneous emission of photoelectrons when radiation is incident on a metal;
Existence of a threshold frequency for photoelectrons to be emitted;
Maximum kinetic energy of emitted electrons depends on frequency but not on intensity of light.

(b) (i) The work function of the emitter $\Phi = hc/\lambda_{max}$
$= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 600 \times 10^{-9}$
$= 3.32 \times 10^{-19}$ J

(ii) $KE_{max} = hc/ \boldsymbol{\lambda_1} - \Phi$
$= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 400 \times 10^{-9} – 3.32 \times 10^{-19}$
$= 1.65 \times 10^{-19}$ J

(iii) $eV_1 = 1.65 \times 10^{-19}$
$V_1 = 1.03$ V

Feedback on Question 10

1.