**Physics 2204**
**June 2009 Exam**

**Part I: Multiple Choice**

| Item | Answer |
|---|---|
| 1 | C |
| 2 | C |
| 3 | A |
| 4 | D |
| 5 | C |
| 6 | C |
| 7 | B |
| 8 | D |
| 9 | B |
| 10 | D |
| 11 | A |
| 12 | D |
| 13 | C |
| 14 | D |
| 15 | B |
| 16 | A |
| 17 | B |
| 18 | A |
| 19 | B |
| 20 | B |
| 21 | C |
| 22 | B |
| 23 | D |
| 24 | B |
| 25 | C |
| 26 | A |
| 27 | D |
| 28 | A |
| 29 | C |
| 30 | C |
| 31 | B |
| 32 | B |
| 33 | C |
| 34 | A |
| 35 | B |
| 36 | B |
| 37 | D |
| 38 | C |
| 39 | D |
| 40 | C |

**Part II: Long Answer**

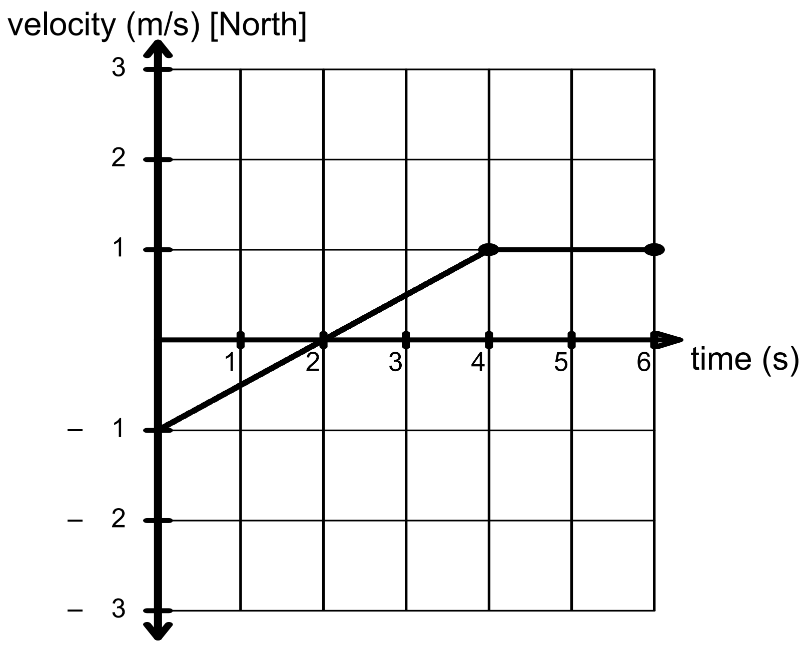
| Item | Cognitive Level | Value |
|---|---|---|
| 41a | L2 | 6 |
| 41b | L3 | 4 |
| 41c | L2 | 4 |
| 42a | L2 | 4 |
| 42b | L2 | 4 |
| 42c | L3 | 4 |
| 42d | L2 | 4 |
| 43a | L2 | 3 |
| 43b | L2 | 3 |
| 43c | L2 | 4 |
| 43d | L3 | 4 |
| 44a | L2 | 2 |
| 44b | L2 | 4 |
| 44c | L2 | 4 |
| 44d | L3 | 3 |
| 44e | L2 | 3 |

**Part II**
**Constructed Response**
**Total Value: 60%**

**Answer ALL questions in the space provided.** ***Show all workings and report all finals answers with correct significant digits and units.***

**Value**

41. a) The motion of an object is graphed below.




2 i) Calculate the magnitude of the acceleration of the object at $t = 2\,s$.

$$Acceleration = slope \quad \text{(1 mark)}$$

$$slope = \frac{1-(-1)\,m/s}{4-0s} = \frac{2\,m/s}{4s} = 0.5\frac{m}{s^2} \quad \text{(1 mark)}$$

2 ii) Calculate the average velocity of the object between $t = 2\,s$ and $t = 4\,s$.

$$\vec{v}_{average} = \frac{\vec{v}_1 + \vec{v}_2}{2} \quad \text{(0.5 marks)}$$

$$\vec{v}_{average} = \frac{0\,m/s + 1\,m/s}{2s} \quad \text{(0.5 marks)}$$

$$\vec{v}_{average} = \frac{1\,m/s}{2s} = 0.5\frac{m}{s}[N] \quad \text{(1 mark)}$$

2 iii) Calculate the distance traveled by the object between $t = 2\,s$ and $t = 6\,s$.

$$Distance = area \quad \text{(0.5 marks)}$$

$$d_{2-4s} = \frac{1}{2}b \times h = \frac{1}{2}(2\,s)(1\,m) = 1\,m \quad \text{(0.5 marks)}$$

$$d_{4-6s} = b \times h = (2\,s)(1\,s) = 2\,m \quad \text{(0.5 marks)}$$

$$d_{Total} = 1\,m + 2\,m = 3\,m \quad \text{(0.5 marks)}$$

4 b) The driver of a car travelling at 25 m/s suddenly sees the lights of a barrier 45 m ahead. It takes the driver 0.75 s to apply the brakes and the acceleration during braking is -9.5 m/s$^2$. Calculate whether the car will hit the barrier.

distance during reaction time:

$$d = vt = (25m/s)(0.75s) = 19m$$ (1 mark)

distance during braking:

$$2ad = {v_2}^2 - {v_1}^2$$

$$d = \frac{{v_2}^2 - {v_1}^2}{2a}$$

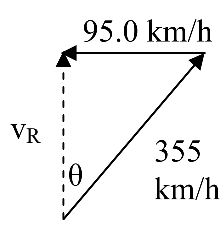
$$d = \frac{0^2 - (25m/s)^2}{2(-9.5m/s^2)} = 33m$$ (1 mark)

total distance:

$$d_{Total} = 19m + 33m = 52m$$ (1 mark)

Since 52 m > 45 m, the car will hit the barrier. (1 mark)

4 c) An aircraft can fly at 355 km/h with respect to the air. The wind is blowing towards the west at 95.0 km/h with respect to the ground. If the pilot wants to land at an airport that is directly north of his present location, calculate the direction in which the plane should head and its speed with respect to the ground. Include a vector diagram in your answer.




(1 mark)

$$v_R{}^2 = v_P^2 - v_W^2$$

$$v_R = \sqrt{(355)^2 - (95)^2}$$ (1 mark)

$$v_R = 342\,km/h$$

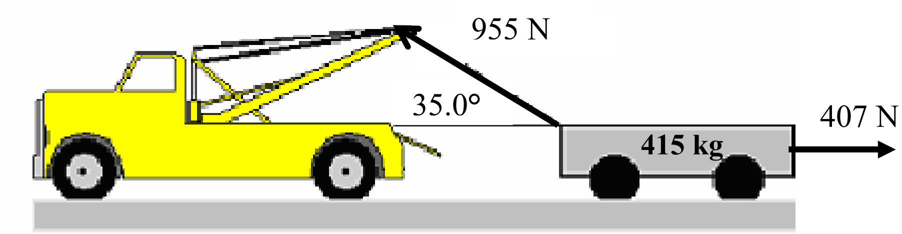
$$\sin\theta = \frac{v_W}{v_P}$$

$$\theta = \sin^{-1}\left(\frac{95.0}{355}\right)$$ (1 mark)

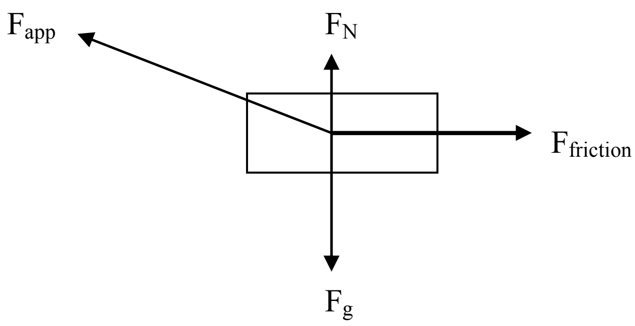
$$\theta = 15.5^o$$

$$\therefore v_R = 342\,km/h\ [N15.5^o\ E]$$ (1 mark)

42. a) A tow truck is applying a 955 N force at 35.0° above the horizontal to a 415 kg cart as shown. The frictional force between the cart and the road is 407 N.




1 i) Draw a free body diagram for the cart.




3 ii) Calculate the magnitude of the acceleration of the cart.

$$F_x = F\cos\theta$$

$$F_x = (955N)\cos(35.0^\circ) \qquad \text{(0.5 marks)}$$

$$F_x = 782N$$

$$F_{Net} = ma$$

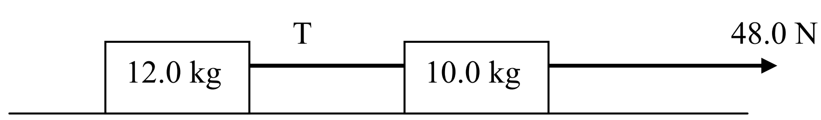
$$F_x - F_{friction} = ma \qquad \text{(1 mark)}$$

$$782N - 407N = (415kg)a$$

$$375N = (415kg)a \qquad \text{(1 mark)}$$

$$\therefore a = 0.904\, m/s^2 \qquad \text{(0.5 marks)}$$

b) Two boxes on a frictionless table are connected by a rope. A force of 48.0 N is applied as shown.




2 i) Calculate the magnitude of the acceleration of the blocks.

$$a = \frac{F_{net}}{m} \qquad \text{(0.5 marks)}$$

$$a = \frac{48.0N}{12.0kg + 10.0kg} \qquad \text{(1 mark)}$$

$$a = 2.18\, m/s^2 \qquad \text{(0.5 marks)}$$

2 ii) Calculate the magnitude of the tension, T, in the connecting rope.

$$\begin{aligned}
&For\ 12.0\ kg\ block, \\
&T = F_{net} && \text{(1 mark)} \\
&T = ma \\
&T = (12.0kg)(2.18m/s^2) && \text{(0.5 marks)} \\
&T = 26.2N && \text{(0.5 marks)}
\end{aligned}$$

OR

$$\begin{aligned}
&For\ 10.0\ kg\ block, \\
&48.0N - T = F_{net} \\
&T = 48.0N - F_{net} && \text{(1 mark)} \\
&T = 48.0N - ma \\
&T = 48.0N - (10.0kg)(2.18m/s^2) && \text{(0.5 marks)} \\
&T = 26.2N && \text{(0.5 marks)}
\end{aligned}$$

c) A 20.0 kg bag of groceries is lifted vertically upwards from the floor to a table. The maximum force the bag can withstand without ripping is 250 N.

1.5 i) Calculate whether the bag will rip if it is lifted at a constant speed.

At constant speed,

$$\begin{aligned}
&F_{app} = mg && \text{(0.5 mar ks)} \\
&F_{app} = (20.0kg)(9.80m/s^2) \\
&F_{app} = 196N && \text{(0.5 marks)}
\end{aligned}$$

The bag will not break since 196 N < 250 N. (0.5 marks)

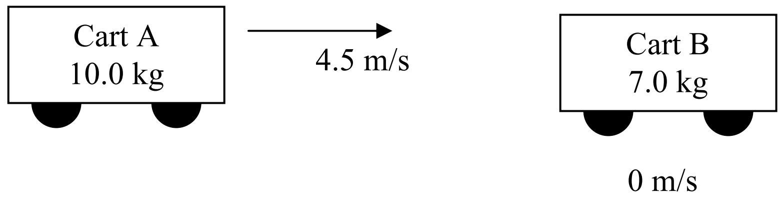
2.5 ii) Calculate whether the bag will rip if is lifted with an acceleration of 5.1 m/s$^2$.

When the bag is accelerated,

$$\begin{aligned}
&F_{app} - mg = F_{net} && \text{(1 mark)} \\
&F_{app} = mg + F_{net} \\
&F_{app} = (20.0kg)(9.80m/s^2) + (20.0kg)(5.1m/s^2) && \text{(0.5 marks)} \\
&F_{app} = 196N + 102N \\
&F_{app} = 298N && \text{(0.5 marks)}
\end{aligned}$$

The bag will break since 298 N > 250 N. (0.5 marks)

4 d) Cart B of mass 7.0 kg is initially at rest. Cart A of mass 10.0 kg approaches cart B with a velocity of 4.5 m/s (E) as shown. If cart A moves at 2.3 m/s (E) after the collision, calculate the velocity of cart B after the collision.




$\overrightarrow{p}_{before} = \overrightarrow{p}_{after}$

$m_A v_A + m_B v_B = m_A' v_A' + m_B' v_B'$ (1 mark)

$(10.0kg)(4.5m/s) + (7.0kg)(0m/s) = (10.0kg)(2.3m/s) + (7.0kg)v_B'$ (2 marks)

$45kg \cdot m/s = 23kg \cdot m/s + (7.0kg)v_B'$

$22kg \cdot m/s = (7.0kg)v_B'$

$v_B' = \dfrac{22kg \cdot m/s}{7.0kg}$ (0.5 marks)

$\therefore \vec{v}_B' = 3.1m/s$ [E] (0.5 marks)

3 43. a) Calculate the amount of work done when an 1150 kg car accelerates from 2.00 m/s to 6.00 m/s.

$W = \Delta E_k$ (1 mark)

$W = \dfrac{mv_2^2}{2} - \dfrac{mv_1^2}{2}$ (0.5 marks)

$W = \dfrac{1150kg(6.00m/s)^2}{2} - \dfrac{1150kg(2.00m/s)^2}{2}$ (1 mark)

$W = 20700J - 2300J$

$W = 18400J$ (0.5 marks)

3 b) A crane with a power output of 3500 W is used to lift a mass of 250 kg. Calculate the time required to lift the mass from the second to the fifth floor if each floor is 4.50 m high.

$P = \dfrac{W}{t}$ (0.5 marks)

$t = \dfrac{W}{P}$ (0.5 marks)

$t = \dfrac{mgh}{P}$ (0.5 marks)

$h = 4.50m \times 3$
$h = 13.5m$ (0.5 marks)

$t = \dfrac{(250kg)(9.80m/s^2)(13.5m)}{3500W}$ (0.5 marks)

$t = 9.5s$ (0.5 marks)

4 c) A 2.00 kg ball is launched vertically upward from the ground with a speed of 55.2 m/s. Calculate the speed of the ball 50.0 m above the ground. Assume that mechanical energy is conserved.

$$\left(E_{Total}\right)_{Bottom} = \left(E_{Total}\right)_{50.0m}$$

$$\left(E_k\right)_{Bottom} = \left(E_k + E_g\right)_{50.0m} \qquad (1\,\text{mark})$$

$$\frac{m{v_{bottom}}^2}{2} = \frac{m{v_{50.0m}}^2}{2} + mgh$$

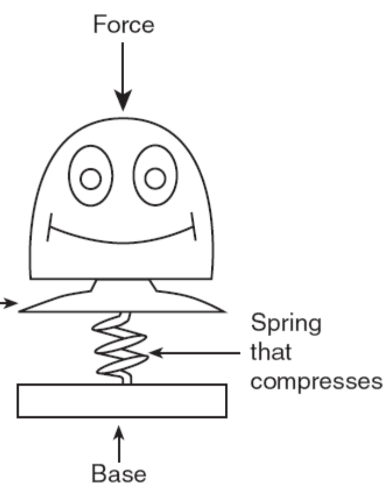
$$\frac{2.00kg(55.2m/s)^2}{2} = \frac{2.00kg(v_{50.0m})^2}{2} + (2.00kg)(9.80m/s^2)(50.0m) \quad (1.5\ \text{marks})$$

$$3047.04\,kg \cdot m^2/s^2 = {v_{50.0m}}^2 + 980\,kg \cdot m^2/s^2 \qquad (1\,\text{mark})$$

$${v_{50.0m}}^2 = 2067.04\,m^2/s^2$$

$$v_{50.0m} = 45.5m/s \qquad (0.5\ \text{marks})$$

4 d) A pop-up toy has a mass of 0.020 kg and a spring constant of 150 N/m as shown. A force is applied to the toy to compress the spring 0.050 m. Calculate whether the toy will hit a 2.1 m high ceiling when it is released.




*Elastic potential energy at the bottom (when compressed) will equal the gravitational potential energy at maximum height.*

$$\left(E_e\right)_{bottom} = \left(E_g\right)_{top} \qquad (1\,\text{mark})$$

$$\frac{kx^2}{2} = mgh \qquad (1\,\text{mark})$$

$$kx^2 = 2mgh$$

$$h = \frac{kx^2}{2mg}$$

$$h = \frac{(150N/m)(0.050m)^2}{2(0.020kg)(9.80m/s^2)} \qquad (0.5\ \text{marks})$$

$$h = 0.96m \qquad (0.5\ \text{marks})$$

The maximum height reached by the pop-toy is 0.96 m which is less than the height of the ceiling. It will not hit the ceiling. (1 mark)

2 44. a) When timing a 100 m race, officials at the finish line are instructed to start their stopwatches at the sight of smoke from the starter's pistol and not at the sound of its firing. Explain why this is necessary.

*Light travels faster than sound.* (1 mark)

*The times would be delayed if officials went by hearing the pistol shots.*

(1 mark)

4 b) An open vertical tube is filled with water. A tuning fork vibrates over its mouth. As the water level is lowered in the tube, resonance is first heard when the water level is 0.170 m from the top of the tube and the next when the water is 0.510 m from the top of the tube. If the air temperature is 22.7°C, calculate the frequency of the tuning fork.

$$v = 332 m/s + 0.6T$$
$$v = 332 m/s + 0.6(22.7^{\circ} C)$$ (1 mark)
$$v = 346 m/s$$

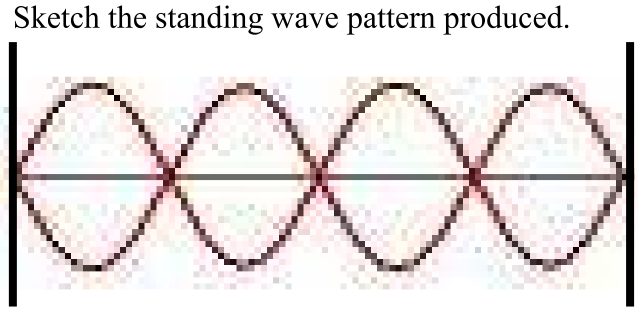
between resonant points is $\frac{1}{2}\lambda$. (1 mark)

$$\frac{1}{2}\lambda = 0.510m - 0.170m$$ (0.5 marks)
$$\frac{1}{2}\lambda = 0.340m$$ (0.5 marks)
$$\lambda = 0.680m$$
$$f = \frac{v}{\lambda}$$
$$f = \frac{346 m/s}{0.680 m}$$ (0.5 marks)

$$f = 509 Hz$$ (0.5 marks)

c) A standing wave pattern containing four antinodes is produced on a 1.2 m long rope.

1 i) Sketch the standing wave pattern produced.



1 ii) Determine the wavelength.

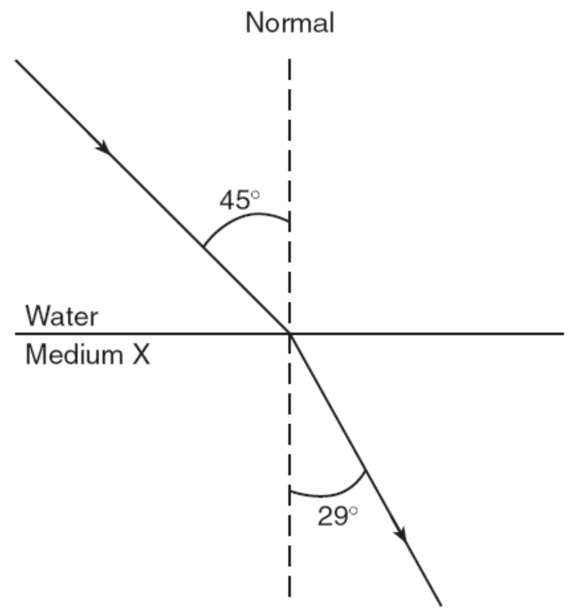
$$2\lambda = 1.2m$$
$$\lambda = \frac{1.2}{2} = 0.60m$$

2 iii) Calculate the frequency of the source if the speed of the wave is 15 m/s.

$$f = \frac{v}{\lambda} = \frac{15 m/s}{0.60 m}$$ (1.5 mark)
$$f = 25 Hz$$ (0.5 marks)

3 d) A ray of light initially travelling in water ( $n = 1.33$ ), is incident on medium X. The angle of incidence in water is 45.0° and the angle of refraction in medium X is 29.0° as shown. Use calculations and the chart shown to identify medium X.

| Material | Index of Refraction |
|---|---|
| diamond | 2.42 |
| glass | 1.50 |
| glycerine | 1.47 |
| zircon | 1.94 |




$n_1 \sin\theta_1 = n_2 \sin\theta_2$ (0.5 marks)

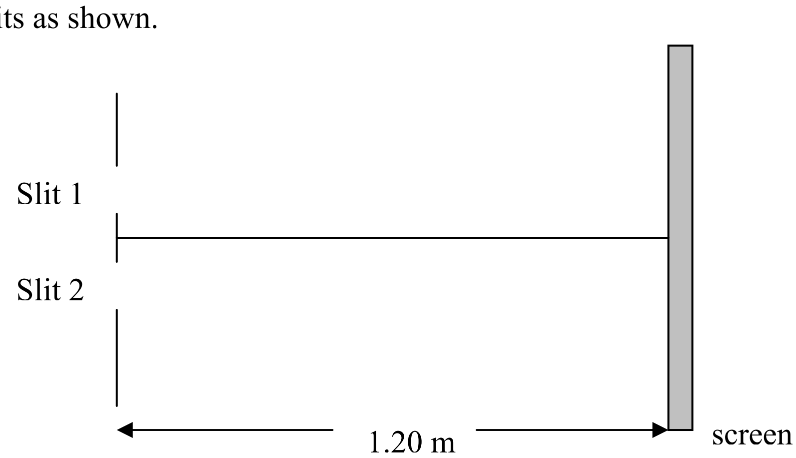
$(1.33)\sin 45.0^\circ = n_2 \sin 29.0^\circ$ (1 mark)

$n_2 = \dfrac{1.33 \sin 45.0^\circ}{\sin 29.0^\circ}$ (0.5 marks)

$n_2 = 1.94$ (0.5 marks)

So medium X is most likely zircon. (0.5 marks)

3 e) Light of wavelength $5.42 \times 10^{-7}$ m shines on two slits that are $1.6 \times 10^{-6}$ m apart. An interference pattern is produced on a screen that is 1.20 m from the slits as shown.




i) Calculate the angle at which the second order maximum occurs.

$n\lambda = d \sin\theta_n$

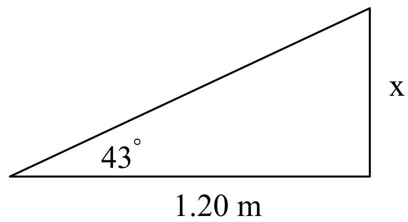
$\sin\theta_2 = \dfrac{n\lambda}{d}$ (0.5 marks)

$\sin\theta_2 = \dfrac{(2)(5.42 \times 10^{-7} m)}{1.6 \times 10^{-6} m}$ (0.5 marks)

$\sin\theta_2 = 0.6775$ (0.5 marks)

$\theta_2 = 43^\circ$ (0.5 marks)

ii) Calculate the distance of the second order maximum from the central bright line on the screen.




$$\tan 43^\circ = \frac{x}{1.20}$$ (0.5 marks)

$$x = 1.20\left(\tan 43^\circ\right)$$

$$x = 1.1m$$ (0.5 marks)

***End of Part II***