# Physics 12

## January 1999 Provincial Examination

## ANSWER KEY / SCORING GUIDE

**CURRICULUM:**

| | **Organizers** | **Sub-Organizers** |
|---|---|---|
| 1. | Vector Kinematics in Two Dimensions | A, B |
| | *and* | |
| | Dynamics *and* Vector Dynamics | C, D |
| 2. | Work, Energy and Power | E |
| | *and* | |
| | Momentum | F, G |
| 3. | Equilibrium | H |
| 4. | Circular Motion | I |
| | *and* | |
| | Gravitation | J |
| 5. | Electrostatics | K, L |
| 6. | Electric Circuits | M, N |
| 7. | Electromagnetism | O, P |

**PART A: Multiple Choice (each question worth TWO marks)**

| **Q** | **K** | **C** | **CO** | **PLO** | **Q** | **K** | **C** | **CO** | **PLO** |
|---|---|---|---|---|---|---|---|---|---|
| 1. | B | K | 1 | A1, K4 | 16. | B | U | 4 | J2, C7 |
| 2. | B | U | 1 | B7, 8 | 17. | B | H | 4 | J10, 6, I4 |
| 3. | B | U | 1 | A6, 7, 8, 9 | 18. | A | K | 5 | K6, 4 |
| 4. | D | K | 1 | D1, 4, 6 | 19. | A | U | 5 | L4 |
| 5. | B | U | 1 | C4, 7, D3 | 20. | C | K | 6 | N3 |
| 6. | C | U | 2 | E10, 5 | 21. | B | U | 6 | N2, M7 |
| 7. | B | U | 2 | F3 | 22. | B | U | 6 | M2, 5 |
| 8. | D | U | 2 | F4 | 23. | C | K | 7 | O2 |
| 9. | A | K | 3 | H7 | 24. | A | U | 7 | O5 |
| 10. | B | U | 3 | H2, 11 | 25. | B | U | 7 | O6 |
| 11. | D | H | 3 | H5, 6 | 26. | B | U | 7 | O8 |
| 12. | D | K | 4 | I1, 3 | 27. | C | U | 7 | P1 |
| 13. | D | U | 4 | I5, 4 | 28. | B | U | 7 | P3 |
| 14. | B | U | 4 | I4, 5 | 29. | C | U | 7 | P5 |
| 15. | D | K | 4 | J8 | 30. | D | H | 7 | O7, 3 |

**Multiple Choice = 60 marks**

**PART B: Written Response**

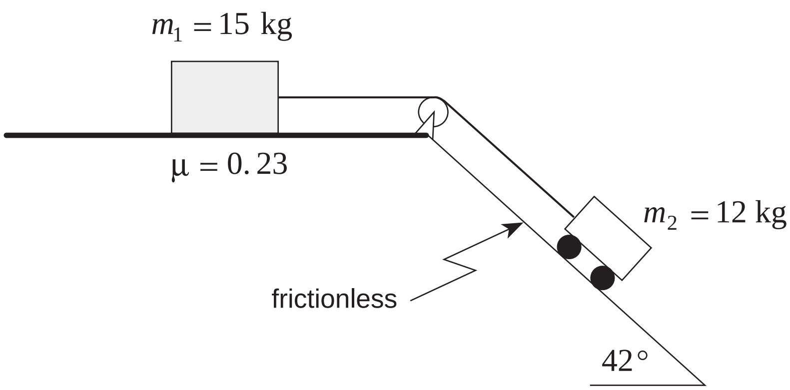
| Q | B | C | S | CO | PLO |
|---|---|---|---|---|---|
| 1. | 1 | U | 7 | 1 | C8, D6 |
| 2. | 2 | U | 7 | 2 | E3, 7, 10 |
| 3. | 3 | U | 7 | 3 | H11 |
| 4. | 4 | U | 7 | 4 | J2, 8, I4 |
| 5. | 5 | U | 7 | 5 | K5, 8 |
| 6. | 6 | U | 9 | 6 | M11, M7 |
| 7. | 7 | U | 7 | 7 | P11, 12 |
| 8 | 8 | H | 5 | 1 | A10, B4 |
| 9. | 9 | H | 4 | 2 | F6 |

**Written Response = 60 marks**

| | | |
|---|---|---|
| Multiple Choice | = | 60 (30 questions) |
| Written Response | = | 60 (9 questions) |
| **EXAMINATION TOTAL** | **=** | **120 marks** |

**LEGEND:**
**Q** = Question Number | **B** = Score Box Number | **C** = Cognitive Level
**CO** = Curriculum Organizer | **K** = Keyed Response | **S** = Score
**PLO** = Prescribed Learning Outcome

1. Two objects are connected as shown. The 12 kg cart is on a frictionless 42° incline while the 15 kg block is on a horizontal surface having a coefficient of friction $\mu = 0.23$.




Determine the acceleration of the system of masses. **(7 marks)**

$$F_f = \mu mg$$

$$= 0.23(15\text{ kg})9.8\text{ m/s}^2$$

$$F_f = 33.8\text{ N} \qquad \leftarrow \textbf{1 mark}$$

$$F_{||} = mg\sin\theta$$

$$= 12\text{ kg}\left(9.8\text{ m/s}^2\right)\sin 42^\circ$$

$$F_{||} = 78.7\text{ N} \qquad \leftarrow \textbf{2 marks}$$

$$a_{system} = \frac{net\ F}{m}$$

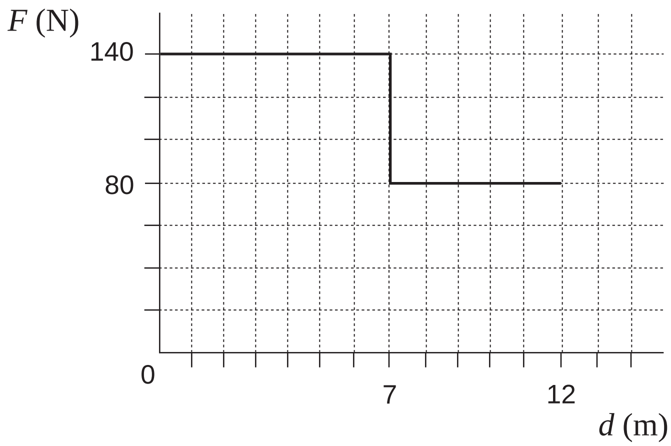
$$= \frac{F_{||} - F_f}{m_1 + m_2}$$

$$= \frac{78.7\text{ N} - 33.8\text{ N}}{12\text{ kg} + 15\text{ kg}} \qquad \leftarrow \textbf{4 marks}$$

$$= 1.66\text{ m/s}^2$$

$$a = 1.7\text{ m/s}^2$$

2. Starting from rest, a farmer pushed a cart 12 m. The graph shows the force $F$ which he applied, plotted against the distance $d$.




a) How much work did the farmer do moving the cart 12 m? **(3 marks)**

$W$ = *area bounded by graph*

$= (140\ \text{N} \times 7.0\ \text{m}) + (80\ \text{N} \times 5.0\ \text{m})$ $\leftarrow$ **2 marks**

$= 980\ \text{J} + 400\ \text{J}$

$= 1\,380\ \text{J}$ $\leftarrow$ **1 mark**

b) After the farmer had pushed the 240 kg cart 12 m, it was moving with a velocity of 2.2 m/s. What was the cart's kinetic energy? **(2 marks)**

$E_k = \frac{1}{2} mv^2$ $\leftarrow$ **1 mark**

$= \frac{1}{2}(240\ \text{kg})(2.2\ \text{m/s})^2$

$= 580\ \text{J}$ $\leftarrow$ **1 mark**

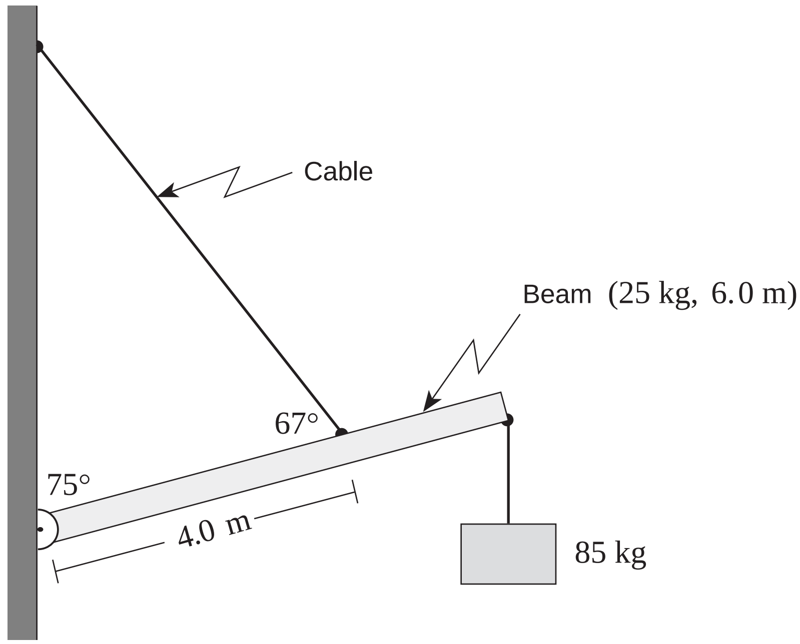
c) What was the efficiency of this process? **(2 marks)**

$Efficiency = \frac{E_{out}}{E_{in}}$ $\leftarrow$ **1 mark**

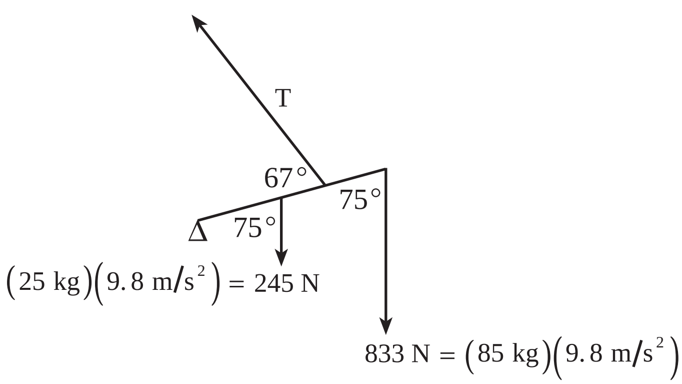
$= \frac{580\ \text{J}}{1\,380\ \text{J}}$

$= 0.42$ or $42\%$ $\leftarrow$ **1 mark**

3. A 6.0 m uniform beam of mass 25 kg is suspended by a cable as shown. An 85 kg object hangs from one end.




What is the tension in the cable? **(7 marks)**




$$\Sigma\tau = 0$$

$$\tau_c = \tau_{cc}$$

$$\tau_{245} + \tau_{833} = \tau_T$$ ← **1 mark**

$$3.0\ \text{m}(245\ \text{N})\sin 75° + 6.0\ \text{m}(833\ \text{N})\sin 75° = 4.0\ \text{m}\ T\sin 67°$$ ← **5 marks**

$$710\ \text{N}\cdot\text{m} + 4\,830\ \text{N}\cdot\text{m} = 3.68\ \text{m}\ T$$

$$5\,540\ \text{N}\cdot\text{m} = 3.68\ \text{m}\ T$$

$$1\,500\ \text{N} = T$$ ← **1 mark**

4. The moon Titan orbits the planet Saturn with a period of $1.4\times10^{6}$ s. The average radius of this orbit is $1.2\times10^{9}$ m.

a) What is Titan's centripetal acceleration? **(2 marks)**

$$\begin{aligned} a_c &= \frac{4\pi^2 r}{T^2} && \leftarrow \textbf{1 mark} \\ &= \frac{4\pi^2 \cdot 1.2\times10^{9}\ \text{m}}{\left(1.4\times10^{6}\ \text{s}\right)^2} \\ &= 2.4\times10^{-2}\ \text{m/s}^2 && \leftarrow \textbf{1 mark} \end{aligned}$$

**($\frac{1}{2}$ mark deducted for not squaring quantities)**

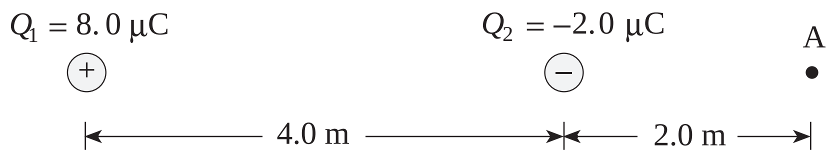
b) Calculate Saturn's mass. **(5 marks)**

$$F_{net} = ma_c$$

$$\frac{Gm_S m_T}{r^2} = \frac{m_T 4\pi^2 r}{T^2} \quad \textbf{OR} \quad \frac{GmM}{r^2} = ma_c \quad \textbf{OR} \quad \text{Kepler's: } \frac{r^3}{T^2} = \frac{GM}{4\pi^2} \quad \leftarrow \textbf{3 marks}$$

$$\begin{aligned} m_S &= \frac{4\pi^2 r^3}{GT^2} \\ &= \frac{4\pi^2\left(1.2\times10^{9}\ \text{m}\right)^3}{6.67\times10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2\left(1.4\times10^{6}\ \text{s}\right)^2} && \leftarrow \textbf{1 mark} \\ &= 5.2\times10^{26}\ \text{kg} && \leftarrow \textbf{1 mark} \end{aligned}$$

5. Two charges are positioned as shown in the diagram below.




a) Find the magnitude and direction of the electric field at A. (Note: $1.0\ \mu C = 1.0 \times 10^{-6}$ C)

**(4 marks)**

$$E_1 = \frac{kQ_1}{r_1^2} = \frac{9.0 \times 10^9 \times 8.0 \times 10^{-6}}{6.0^2} = 2.0 \times 10^3 \text{ N/C to the right}$$ ← **1 $\frac{1}{2}$ marks**

$$E_2 = 4.5 \times 10^3 \text{ N/C to the left}$$ ← **1 $\frac{1}{2}$ marks**

$$E = 2.5 \times 10^3 \text{ N/C to the left}$$ ← **1 mark**

b) A charge placed at A experiences a force of $4.0 \times 10^{-3}$ N towards the right. What are the magnitude and polarity of this charge?

**(3 marks)**

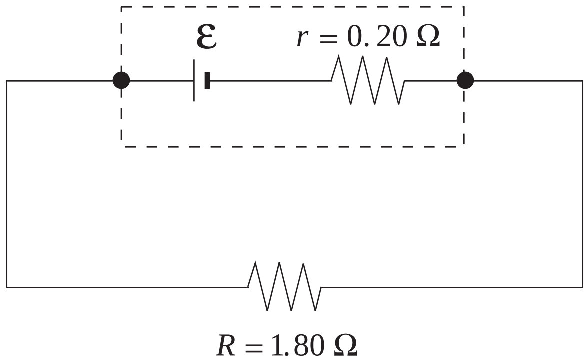
$$E = \frac{F}{q} \rightarrow q = \frac{F}{E}$$ ← **1 mark**

$$= \frac{4.0 \times 10^{-3} \text{ N}}{2.5 \times 10^3 \text{ N/C}}$$ ← **1 mark**

$$= 1.6 \times 10^{-6} \text{ C, negative}$$ ← **1 mark**

Answer: $-1.6 \times 10^{-6}$ C

6. The cell shown delivers a $1.50\ \text{A}$ current to the external circuit and has a terminal voltage of $2.70\ \text{V}$.




a) What is the emf of the cell? **(4 marks)**

$V = \varepsilon - Ir$ ← **1 mark** **OR** $\varepsilon = R_T I$

$2.70\ \text{V} = \varepsilon - 1.50\ \text{A}(0.20\ \Omega)$ ← **2 marks** $= (1.8 + 0.2)1.5$

$\varepsilon = 3.00\ \text{V}$ ← **1 mark** $= 3.0\ \text{V}$

b) The $1.80\ \Omega$ external resistance is replaced by other resistors and the current and terminal voltage are measured in each case. Which graph best represents terminal voltage $V_T$ versus current $I$ as these resistors are changed? **(2 marks)**

**Graph III**

c) Using principles of physics, explain your answer to b). **(3 marks)**

**If $R$ is increased in value the total resistance of the circuit increases, and the current $I$ decreases. There is then a smaller potential difference across $r$ so that the terminal voltage is larger. Alternatively, decreasing $R$ will raise $I$ and lower $V$. Graph III reflects this trend.**

7. An electric device operates on $9.0\ \text{V ac}$ and has a total resistance of $21\ \Omega$. An ideal transformer is used to change the incoming line voltage of $120\ \text{V ac}$ to the operating voltage of $9.0\ \text{V ac}$.

a) Is the transformer a step-up or step-down transformer? **(1 mark)**

**Step-down**

b) What is the current in the primary side? **(6 marks)**

$$I = \frac{V}{R} = \frac{9.0\ \text{V}}{21\ \Omega}$$ ← **1 mark**

$$= 0.43\ \text{A}$$ ← **1 mark**

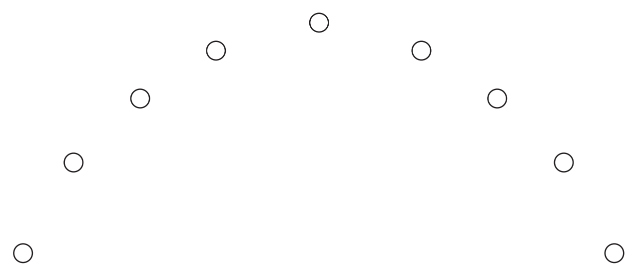
$$P_1 = P_2$$ ← **1 mark**

$$V_1 I_1 = V_2 I_2$$ ← **1 mark**

$$I_1 = \frac{9.0\ \text{V} \times 0.43\text{A}}{120\ \text{V}}$$ ← **1 mark**

$$= 0.032\ \text{A}$$ ← **1 mark**

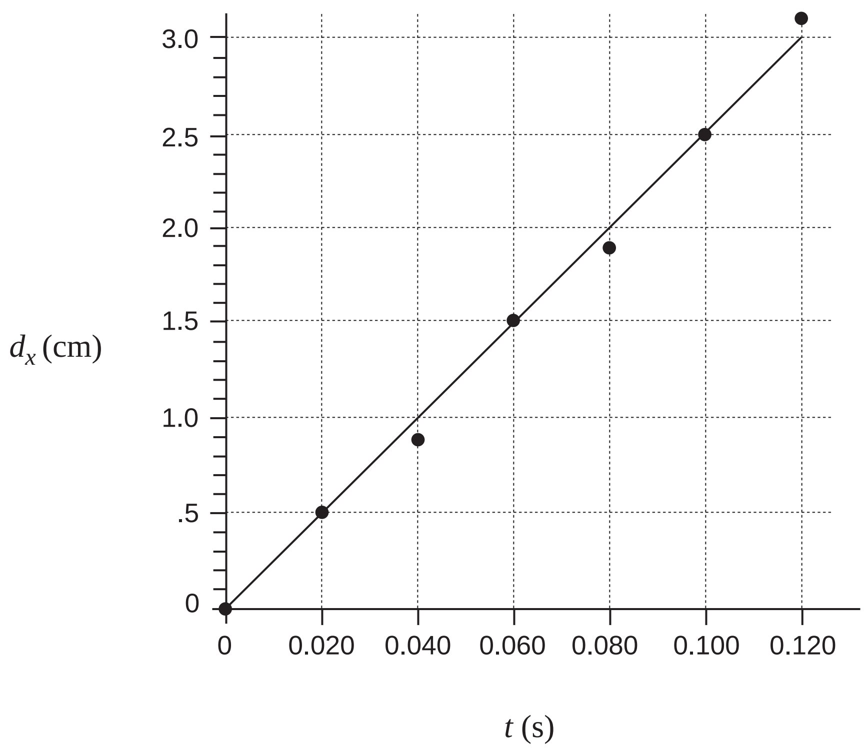
8. A student collects data from the path of a projectile similar to that shown in the diagram.



The student records the following data for horizontal displacement from the initial launch position as a function of time.

| $d_x$ (cm) | 0.0 | 0.5 | 0.9 | 1.5 | 1.9 | 2.5 | 3.1 |
|---|---|---|---|---|---|---|---|
| $t$ (s) | 0.000 | 0.020 | 0.040 | 0.060 | 0.080 | 0.100 | 0.120 |

a) Plot a graph of $d_x$ vs. $t$ on the graph below. **(2 marks)**



b) Calculate the slope of the line, expressing the answer in appropriate units. **(2 marks)**

$$slope = \frac{2.5\ \text{cm}}{0.1\ \text{s}} = 25\ \text{cm/s}$$

c) Based on this data and graph, make a statement about the behaviour of projectiles. **(1 mark)**

**The horizontal speed of projectiles is constant.**

9. Consider the collision between the vehicles in the photograph below.


The collision is inelastic. Define inelastic. Give at least two pieces of evidence that show this to be an inelastic collision. **(4 marks)**

**In inelastic collisions, kinetic energy is not conserved.**

**In collisions between cars there are skid marks, dents, pieces of twisted metal and loud sounds.**

**Each of these requires energy. This energy comes from the original kinetic energy.**

**Since an elastic collision requires conservation of kinetic energy, any collision producing one or more of the above observations must be inelastic.**

**END OF KEY**