UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 117.3
MIDTERM TEST
ALTERNATIVE

February 2012 | Time: 90 minutes

NAME: MASTER
(Last) **Please Print** (Given)

STUDENT NO.: ___________

LECTURE SECTION (please check):

- ❑ 01 B. Zulkoskey
- ❑ 02 Dr. J-P St. Maurice
- ❑ C15 F. Dean

INSTRUCTIONS:

1. This is a closed book exam.
2. The test package includes a test paper (this document), a formula sheet, and an OMR sheet. The test paper consists of 8 pages. **It is the responsibility of the student to check that the test paper is complete**.
3. Only Hewlett-Packard hp 10S or 30S or Texas Instruments TI-30X series calculators, or a calculator approved by your instructor, may be used.
4. Enter your name and student number on the cover of the test paper and check the appropriate box for your lecture section. Also enter your student number in the top right-hand corner of each page of the test paper.
5. Enter your name and STUDENT NUMBER on the OMR sheet.
6. The test paper, the formula sheet and the OMR sheet must all be submitted.
7. The test paper will be returned. The formula sheet and the OMR sheet will NOT be returned.

ONLY THE THREE PART B QUESTIONS THAT YOU INDICATE WILL BE MARKED

PLEASE INDICATE WHICH THREE PART B QUESTIONS ARE TO BE MARKED

QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-15	-	15	
B1	❑	10	
B2	❑	10	
B3	❑	10	
B4	❑	10	
TOTAL		45	

continued on page 2...

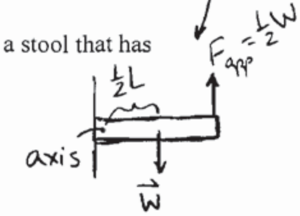
PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

C

A1. A uniform bar of length L and weight W is attached to a vertical wall by a frictionless hinge. Which one of the following scenarios can result in the bar being horizontal and stationary?

(A) A force of magnitude W is applied vertically upward to the bar at a distance of L from the hinge.
(B) A force of magnitude W is applied horizontally to the bar at a distance of L from the hinge.
(C) A force of magnitude ½W is applied vertically upward to the bar at a distance of L from the hinge.
(D) A force of magnitude ½W is applied vertically upward to the bar at a distance of ½L from the hinge.
(E) A force of magnitude W is applied horizontally to the bar at a distance of ½L from the hinge.



Want $\Sigma\tau = 0$

E

A2. A student holding a pair of dumbbells in his outstretched arms is rotating on a stool that has frictionless bearings. When the student pulls his arms closer to his body…

(A) both his angular momentum and his angular velocity increase.
(B) his angular momentum increases and his angular velocity decreases.
(C) both his angular momentum and his angular velocity decrease.
(D) both his rotational inertia and his angular velocity increase.
(E) his angular momentum remains constant and his angular velocity increases.

Cons. of Ang. Momentum
$I_i\omega_i = I_f\omega_f$

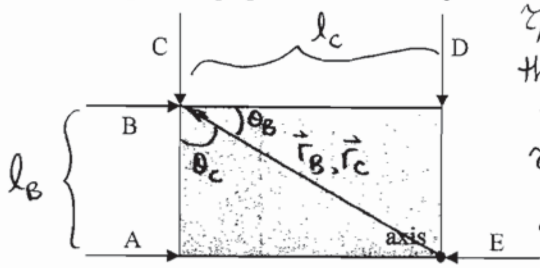
E

A3. Which one of the following statements is **TRUE**?

(A) If the net force on an object is zero then the net torque on the object must also be zero. F
(B) If the net torque on an object is zero then the net force on the object must also be zero. F
(C) If the net force on an object is zero then the object cannot be rotating. F
(D) If the net torque on an object is zero then the centre of mass of the object must be stationary. F
(E) If the net force on an object is zero and the net torque on the object is zero then the object is in rotational equilibrium (no translational acceleration and no angular acceleration) T

C

A4. Five forces, A, B, C, D, and E, all of equal magnitude, act on a rectangular object as shown below. Which force produces the largest magnitude of torque if the axis of rotation is through the lower right corner of the object and perpendicular to the object?



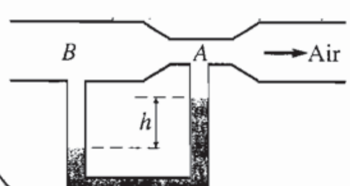
$\tau_A = \tau_D = \tau_E = 0$ b/c the forces act through the axis.
$\tau_c > \tau_B$ b/c $l_c > l_B$
or b/c $\theta_c > \theta_B$

(A) A (B) B (C) C (D) D (E) E

E

A5. Air is flowing into a Venturi meter (see figure). The narrow section of the pipe at point A has a diameter that is ½ of the diameter of the larger section of the pipe at point B. The U-shaped tube is filled with water. If the air speed at B is υ, how fast is the air moving at point A?

(A) ¼ υ (B) ½ υ (C) υ (D) 2 υ (E) 4 υ



Continuity Eq'n:
$A_B\upsilon_B = A_A\upsilon_A$
$\frac{\pi d_B^2}{4}\upsilon_B = \frac{\pi d_A^2}{4}\upsilon_A$

$\upsilon_A = \left(\frac{d_B}{d_A}\right)^2 \upsilon_B$

$\upsilon_A = \left(\frac{d_B}{\frac{1}{2}d_B}\right)^2 \upsilon_B = 4\upsilon_B$

continued on page 3...

A6. Which has a greater buoyant force on it, a 25 cm^3 piece of wood floating with part of its volume above water or a 25 cm^3 piece of submerged iron?

B

(A) The floating wood.
(B) The submerged iron.
(C) They each experience the same buoyant force.
(D) It is impossible to say without knowing their weights.
(E) It is impossible to say without knowing the depth of the piece of submerged iron.

$F_B = \rho_f g V_f$

submerged iron displaces more water than floating wood.

A7. A viscous fluid is flowing steadily through a pipe of radius r. Suppose you replace it by two parallel pipes, each of radius ½ r, but the same length as the original pipe. If the pressure difference between the ends of these two pipes is the same as for the original pipe, what is the total rate of flow in the two pipes compared to the original flow rate, Q_1?

A

$Q_1 = \frac{\Delta V}{\Delta t} = \frac{\pi}{8} \frac{\Delta P/L}{\eta} r^4$

(A) $\frac{1}{8}Q_1$ (B) $\frac{1}{4}Q_1$ (C) $\frac{1}{2}Q_1$ (D) Q_1 (E) $2Q_1$

For each new pipe, $Q = \frac{\pi}{8}\frac{\Delta P/L}{\eta}\left(\frac{1}{2}r\right)^4 = \frac{1}{16}Q_1$ so $Q_{new} = 2\left(\frac{1}{16}Q_1\right)$

A8. An object attached to a spring is undergoing simple harmonic motion. Which one of the following statements is **FALSE**?

A

(A) The object's acceleration is maximum at the equilibrium position. F
(B) The restoring force always acts to return the spring to its equilibrium position. T
(C) The object's velocity is instantaneously zero at maximum displacement. T
(D) The object's velocity is maximum at the equilibrium position. T
(E) The restoring force is always directed opposite to the displacement from equilibrium. T

$F = -kx$

A9. Which one of the following statements is **FALSE**?

C

(A) An object in equilibrium can still be deformed by forces. T
(B) An elastic object can return to its original shape, provided the applied force is not too large. T
(C) A tensile (stretching) force applied to the ends of a wire exerts a shear stress on the wire. F
(D) Tensile strain is the fractional change in length. T
(E) Strain is a dimensionless measure of the deformation of an object. T

$\frac{F}{A} = Y\frac{\Delta L}{L}$

A10. A force F applied to each end of a steel wire (length L, diameter d) stretches it by ΔL. How much does the same force F stretch another steel wire of length $2L$ and diameter $2d$?

B

(A) ¼ ΔL (B) ½ ΔL (C) ΔL (D) 2 ΔL (E) 4 ΔL

$\Delta L = \frac{FL}{AY}$

$\Delta L' = \frac{F(2L)}{(4A)Y} = \frac{1}{2}\Delta L$

A11. A thin circular hoop is suspended from a knife edge as shown in the figure. Its rotational inertia about the rotation axis (along the knife edge) is $I = 2MR^2$. You want to compare its frequency of oscillation to that of a simple pendulum that has its mass suspended at a distance equal to the radius of the hoop. Let f be the frequency of oscillation of the simple pendulum. The frequency of oscillation of the hoop is

B

$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$

(A) $\frac{f}{2}$ (B) $\frac{f}{\sqrt{2}}$ (C) f (D) $\sqrt{2}f$ (E) $2f$

$f_{hoop} = \frac{1}{2\pi}\sqrt{\frac{mgd}{I}} = \frac{1}{2\pi}\sqrt{\frac{MgR}{2MR^2}} = \frac{1}{2\pi}\sqrt{\frac{g}{2R}} = \frac{1}{\sqrt{2}}\left(\frac{1}{2\pi}\sqrt{\frac{g}{R}}\right) = \frac{1}{\sqrt{2}} \cdot f$

A12. A sound source radiates sound uniformly in all directions. The power of the source is constant. The sound intensity is I at a distance of r from the source. The intensity at a distance of $2r$ is

A

(A) ¼ I (B) ½ I (C) I (D) 2 I (E) 4 I

$I = \frac{P}{4\pi r^2}$

A13. Two speakers, separated by a distance d, are producing coherent sound waves that are in phase at a point P that is the same distance from each speaker. The wavelength of the sound being produced is λ. Point Q is a distance r_1 from speaker 1 and a distance r_2 from speaker 2. Which one of the following conditions will ensure that the sound waves from the speakers interfere destructively at Q?

E

(A) $|r_2 - r_1| = 2d$ (B) $|r_2 - r_1| = d$ (C) $|r_2 - r_1| = ½\, d$ (D) $|r_2 - r_1| = \lambda$ (E) $|r_2 - r_1| = ½\, \lambda$

Constructive interference at P means the two sources are in phase. Destructive interference will occur at Q for $|r_2 - r_1| = \frac{1}{2}\lambda$

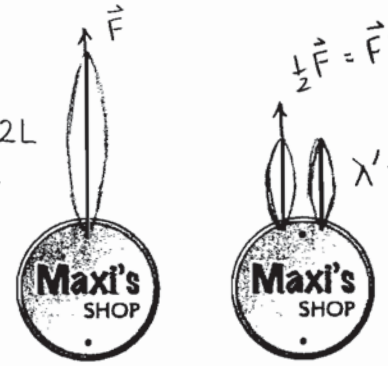
continued on page 4...

A14. A sign is hanging from a single metal wire, as shown in the left part of the accompanying figure. The shop owner notices that the wire vibrates at a fundamental resonance frequency of *f*, which irritates his customers. In an attempt to fix the problem, the shop owner cuts the wire in half and hangs the sign from the two halves, as shown in the right part of the figure. Assuming the tension in each of the two wires is now half the original tension, what is the new fundamental frequency of each wire?

D

$\lambda_1 = 2L$

$f = \frac{v}{\lambda} = \frac{1}{2L}\sqrt{\frac{F}{\mu}}$



$\lambda' = 2L' = 2(\frac{1}{2}L) = L$

$f' = \frac{v'}{\lambda'} = \frac{1}{L}\sqrt{\frac{F'}{\mu}}$

$f' = \frac{1}{L}\sqrt{\frac{\frac{1}{2}F}{\mu}} = \frac{1}{L}\frac{1}{\sqrt{2}}\sqrt{\frac{F}{\mu}}$

(A) $\frac{f}{2}$ (B) $\frac{f}{\sqrt{2}}$ (C) f (D) $\sqrt{2}f$ (E) $2f$

$f' = \frac{1}{\sqrt{2}}\, 2\left(\frac{1}{2L}\sqrt{\frac{F}{\mu}}\right)$

$f' = \frac{2}{\sqrt{2}} f = \sqrt{2} f$

A15. The accompanying figure shows a snapshot of a transverse wave moving to the left on a string. The wave speed is 10.0 m/s and to the left, as shown. At the instant the snapshot is taken, in what directions are points *A* and *B* moving?

C

(A) They are both moving to the left.
(B) They are both moving up.
(C) Point *A* is moving up while point *B* is moving down.
(D) Point *A* is moving down while point *B* is moving up.
(E) They are both moving down.

PART B

ANSWER THREE OF THE PART B QUESTIONS ON THE FOLLOWING PAGES AND INDICATE YOUR CHOICES ON THE COVER PAGE.

FOR EACH OF YOUR CHOSEN PART B QUESTIONS ON THE FOLLOWING PAGES, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

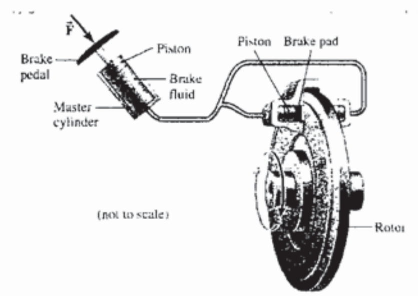
SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.

continued on page 5...

B1. Depressing the brake pedal in a truck pushes on a piston with a cross-sectional area of 2.00 cm^2. The piston applies pressure to the brake fluid, which is connected to two pistons, each with area of 12.0 cm^2. Each of the pistons presses a brake pad against one side of a rotor attached to one of the wheels. See the figure.



(a) When a 7.50 N force is applied to the small piston (that is, the brake pedal), what will be the force, in N, applied to each side of the rotor? (2 marks)

Pascal's Principle ΔP is the same throughout the brake fluid.

$\boxed{45.0 \text{ N}}$

$$\Delta P = \frac{\Delta F}{A} = \frac{7.50\text{N}}{2.00\text{cm}^2} \cdot \left(\frac{100\text{ cm}}{\text{m}}\right)^2 = 3.75 \times 10^4 \text{ Pa}$$

$$\therefore \Delta F_{pad} = \Delta P \cdot A_{\substack{rotor \\ piston}} = (3.75 \times 10^4 \text{Pa})(12.0 \text{ cm}^2)\left(\frac{1 \text{ m}}{100 \text{ cm}}\right)^2 = 45.0 \text{N}$$

(b) If the coefficient of kinetic friction between a brake pad and the rotor is 0.800 and each pad is 23 cm away from the rotation axis of the rotor, what is the torque on the rotor due to the two pads? If you did not obtain an answer for (a) use a value of 55 N for the force applied on each side of the rotor. (3 marks)

$\boxed{16.6 \text{ N}\cdot\text{m}}$

$$\tau_{tot} = f_{k_1} \cdot r_1 + f_{k_2} \cdot r_2$$

$$\tau_{tot} = 2\mu_k \Delta F_{pad} \cdot r = 2(0.800)(45.0\text{N})(0.230\text{m}) = 16.6 \text{ N}\cdot\text{m}$$

(c) Assume the truck is moving at 100 km/hr when the brake pedal is applied. Assume that the radius of the wheel to which the rotor is attached is 35.0 cm. Calculate the angular frequency of the rotor in this case. (2 marks)

$\boxed{79.4 \text{ rad/s}}$

$$v = v_t = R\omega$$

$$\omega = \frac{v}{R} = \frac{100 \text{ km/h}}{0.350\text{ m}} \times \frac{1000\text{ m}}{\text{km}} \cdot \frac{1\text{ h}}{3600\text{ s}} = 79.4 \text{ rad/s}$$

(d) Assume that the rotational inertia of the wheel plus rotor is 2.00 kg-m^2. At the moment when the brakes are first applied, what is the power in kW that is applied to the wheel through the brakes? If you did not get answer for the torque use a value of 20.0 N-m. If you did not get an answer for part (c), use 50.0 rad/s for the angular frequency. (3 marks)

$\boxed{1.32 \text{ kW}}$

$$P = \tau\omega$$

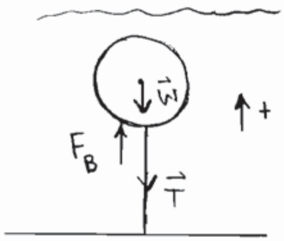
$$P = (16.6 \text{ N}\cdot\text{m})(79.4 \text{ rad/s}) = 1.32 \times 10^3 \text{ W} = 1.32 \text{ kW}$$

continued on page 6...

B2. A ~~plastic sphere~~ large ball is held below the surface of a swimming pool by a cord anchored to the bottom of the pool. The ~~sphere~~ ball has a volume of 1.41×10^{-2} m^3 and the tension in the cord is 124 N.

(a) Calculate the buoyant force exerted by the water on the ~~sphere~~ ball. (3 marks)

$\boxed{138\text{ N}}$



$$F_B = \rho_f g V_f$$

$$V_f = V_{sphere} \text{ since submerged}$$

$$F_B = (1000\text{ kg/m}^3)(9.80\text{ m/s}^2)(1.41 \times 10^{-2}\text{ m}^3)$$

$$F_B = 138\text{ N}$$

(b) Calculate the mass of the ~~sphere~~ ball. (3 marks)

$\boxed{1.43\text{ kg}}$

$$\text{Equilibrium} \Rightarrow \sum \vec{F} = 0$$

$$F_B - W - T = 0$$

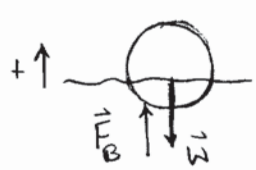
$$F_B - T = W$$

$$F_B - T = mg$$

$$m = \frac{F_B - T}{g} = \frac{138\text{N} - 124\text{N}}{9.80\text{ m/s}^2} = 1.43\text{ kg}$$

(c) The cord breaks and the ~~sphere~~ ball rises to the surface. When the ~~sphere~~ ball comes to rest, calculate the percentage of its volume that is submerged. (4 marks)

$\boxed{10.1\%}$



$$\text{Equilibrium} \Rightarrow \sum \vec{F} = 0$$

$$F_B - W = 0$$

$$\rho_f g V_f - mg = 0$$

V_f = volume of displaced fluid = volume of ball that is submerged

$$\rho_f g V_f - \rho_b V_b g = 0 \Rightarrow \rho_f V_f = \rho_b V_b$$

$$\frac{V_f}{V_b} = \frac{\rho_b}{\rho_f} \text{ and } \rho_b = \frac{m_b}{V_b}$$

$$\frac{V_f}{V_b} \times 100\% = \frac{m_b/V_b}{\rho_f} \times 100\% = \frac{1.43\text{ kg}/1.41 \times 10^{-2}\text{ m}^3}{1000\text{ kg/m}^3} = 10.1\%$$

continued on page 7...

B3. A 250 g object on a spring oscillates left to right on a frictionless surface with a frequency of 5.00 Hz. Its position as a function of time is given by $x = (10.0 \text{ cm}) \sin(\omega t)$.

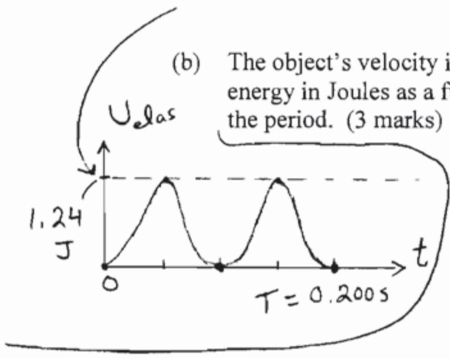
(a) Sketch a graph of the elastic potential energy as a function of time. Use Joules for your energy units. Include numerical labels for the maximum energy and the period. (3 marks)

$m = 0.250 \text{ kg}$, $f = 5.00 \text{ Hz} \Rightarrow \omega = 2\pi f = 31.4 \text{ rad/s}$

$\omega = \sqrt{\frac{k}{m}} \Rightarrow k = \omega^2 \cdot m = (31.4 \text{ rad/s})^2 (0.250 \text{ kg}) = 247 \text{ kg/s}^2$

$U_{elastic} = \frac{1}{2} k x^2 = \frac{1}{2}(247 \text{ kg/s}^2)(0.100 \text{ m})^2 \sin^2(31.4t)$

$U_{elastic} = 1.24 \text{ J} \sin^2(31.4t)$; $T = \frac{1}{f} = \frac{1}{5.00 \text{ Hz}} = 0.200 \text{ s}$



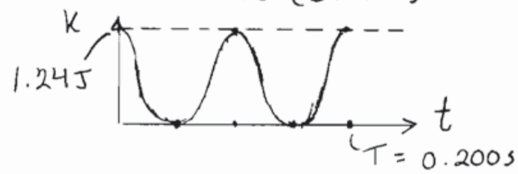
(b) The object's velocity is given by $v_x = \omega (10.0 \text{ cm}) \cos(\omega t)$. Graph the system's kinetic energy in Joules as a function of time. Include numerical labels for the maximum energy and the period. (3 marks)

$v_x = (31.4 \text{ rad/s})(0.100 \text{ m}) \cos(31.4t)$

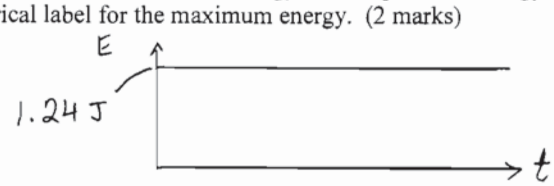
$v_x = (3.14 \text{ m/s}) \cos(31.4t)$

$K = \frac{1}{2} m v_x^2 = \frac{1}{2}(0.250 \text{ kg})(3.14 \text{ m/s})^2 \cos^2(31.4t)$

$K = 1.24 \text{ J} \cos^2(31.4t)$



(c) Graph the sum of the kinetic energy and the potential energy as a function of time. Include a numerical label for the maximum energy. (2 marks)



$E_{tot} = U_{elas} + K = 1.24 \text{ J}$ b/c $\sin^2 + \cos^2 = 1$.

(d) Describe in words how your last answer would change if the surface weren't frictionless. (2 marks)

The total energy will decrease steadily with time as mechanical energy is converted into heat.

continued on page 8...

B4. A string of length 1.50 m is fixed at both ends. Its mass per unit length is 1.20 g/m and the tension is 12.0 N.

(a) Calculate the speed of a transverse wave on this string. (2 marks)

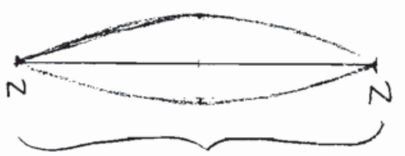
$\boxed{1.00 \times 10^{2}\,\text{m/s}}$

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{12.0\,\text{N}}{1.20 \times 10^{-3}\,\text{kg/m}}}$$

$$v = 1.00 \times 10^{2}\,\text{m/s}$$

(b) Calculate the wavelength associated with the fundamental frequency of oscillation for this string. (2 marks)

$\boxed{3.00\,\text{m}}$



$$L = \tfrac{1}{2}\lambda \Rightarrow \lambda = 2L = 2(1.50\,\text{m}) = 3.00\,\text{m}$$

(c) Calculate the fundamental frequency of oscillation for the string. (2 marks)

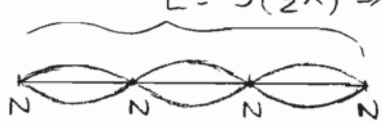
$\boxed{33.3\,\text{Hz}}$

$$f = \frac{v}{\lambda} = \frac{1.00 \times 10^{2}\,\text{m/s}}{3.00\,\text{m}} = 33.3\,\text{Hz}$$

(d) Calculate the tension required for the $n = 3$ mode to have a frequency of 0.150 kHz. (4 marks)

$$L = 3\left(\tfrac{1}{2}\lambda\right) \Rightarrow \lambda = \tfrac{2}{3}L$$

$\boxed{27.0\,\text{N}}$



$$f = \frac{v}{\lambda} = \frac{3}{2L}\sqrt{\frac{F}{\mu}} \Rightarrow \frac{4f^2L^2}{9}\cdot\mu = F$$

$$F = \frac{4(150\,\text{Hz})^2(1.50\,\text{m})^2}{9} \cdot 1.20 \times 10^{-3}\,\text{kg/m} = 27.0\,\text{N}$$

END OF EXAMINATION