Section A Answer sheet	1	2	3	4	5	6	7	8	9	10

For your information

$sin\theta = \frac{m\lambda}{d}$ $m = 0, 1, 2, 3 \ldots.$ $sin\theta = \frac{(m+\frac{1}{2})\lambda}{d}$ $m = 0, 1, 2, 3 \ldots.$ $sin\theta = \frac{m\lambda}{W}$ $m = 0, 1, 2, 3 \ldots.$

Section A: Multiple Choice Questions [20]

1. Which one of the following statements most accurately describes the centre of gravity of an object?

A) It is the point where gravity acts on the object.

B) It is the point where all the mass is concentrated.

C) It must be experimentally determined for all objects.

D) It is the point on the object where all the weight is concentrated.

E) It is the point from which the torque produced by the weight of the object can be calculated.

2. Which equation is valid *only* when the angular measure is expressed in *radians*?

A) $\alpha = \frac{\Delta\omega}{\Delta t}$

B) $\omega = \frac{\Delta\theta}{\Delta t}$

C) $\omega^2 = \omega_0^2 + 2\alpha\theta$

D) $\omega = \frac{v_T}{r}$

E) $\theta = \frac{1}{2}\alpha t^2 + \omega_0 t$

3. Which one of the following statements is true concerning an object executing simple harmonic motion?

A) The object's velocity is never zero.

B) The object's acceleration is never zero.

C) The object's velocity and acceleration are simultaneously zero.

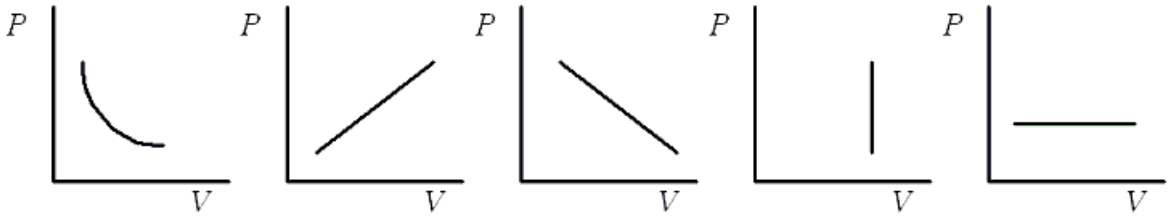
D) The object's velocity is zero when its acceleration is a maximum.
E) The object's maximum acceleration is equal to its maximum velocity.

4. Complete the following sentence: The operation of a hydraulic jack is an application of
A) Pascal's principle.
B) Bernoulli's principle.
C) Archimedes' principle.
D) irrotational flow.
E) the continuity equation

5. Complete the following statement: Walls that separate a system from its surroundings and permit heat to flow through them are called
A) diathermal walls.
B) adiabatic walls.
C) entropic walls.
D) isobaric walls.
E) isochoric walls

6. A match ignites within in an oxygen-filled cylinder that has a movable piston. The piston is moved so quickly that no heat escapes. What kind of change is demonstrated in this process?
A) an isobaric change
B) an adiabatic change
C) an isothermal change
D) an isochoric change
E) a change of heat capacity

7. Which one of the following pressure-volume graphs represents an *isochoric* process?



A) (a)

B) (b)

C) (c)

D) (d)

E) (e)

8. Two identical light waves, A and B, are emitted from different sources in phase and meet at a point P. The distance from the source of A to the point P is L_A; and the source of B is a distance L_B from P. Which one of the following statements is necessarily true concerning the interference of the two waves?

A) A and B will interfere constructively because their amplitudes are the same.

B) A and B will interfere constructively if $L_A = L_B$.

C) A and B will interfere destructively if $L_A - L_B = ml$ where m = 0, 1, 2, 3, ...

D) A and B will interfere destructively if L_A is not equal to L_B.

E) A and B will interfere constructively because their wavelengths are the same.

9. Which one of the following systems would constitute an inertial reference frame?

A) a weather balloon descending at constant velocity

B) a rocket undergoing uniform acceleration

C) a roller coaster traveling around a corkscrew turn at constant speed

D) an orbiting space station

E) a rotating merry-go-round

10. Which one of the following statements concerning the *proper time interval* between two events is true?

A) The proper time interval is the longest time interval that any inertial observer can measure for the event.

B) The proper time interval is the shortest time interval that any inertial observer can measure for the event.

C) The proper time interval is the time measured by an observer who is in motion with respect to the event.

D) The proper time interval depends upon the speed of the observer.

E) The proper time interval depends upon the choice of reference frame.

Questions 1: Rotational Kinematics and Rotational Dynamics [10]

1.1 Is it possible for a large force to produce a small or even a zero torque and for a small force to produce a large torque? Explain your answer using suitable examples. (2)

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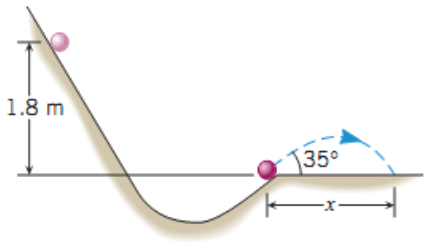
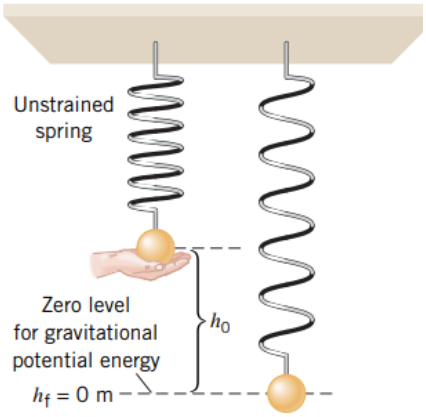
1.2 A tennis ball, starting from rest, rolls down the hill in as shown on the drawing. At the end of the hill the ball becomes airborne, leaving at an angle of 35° with respect to the ground. Treat the ball as a thin-walled spherical shell with moment of inertia $I=\frac{2}{3}mr^2$, and then calculate the distance x covered by the ball while in air. (8)

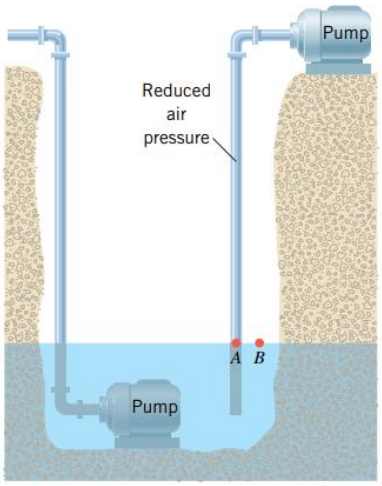


Question 2: Simple Harmonic Motion and Fluids **[5]**

2.1 A 0.20-kg ball is attached to a vertical spring, as shown. The spring constant of the spring is 28 N/m. The ball, supported initially so that the spring is neither stretched nor compressed, is released from rest. In the absence of air resistance, how far does the ball fall before being brought to a momentary stop by the spring? (5)



2.2 The diagram shows two methods for pumping water from a well. In one method, the pump is submerged in the water at the bottom of the well, while in the other, it is located at ground level. If the well is shallow, either technique can be used. However, if the well is very deep, only one of the methods works. Which pumping method works, (a) the submerged pump or (b) the pump located at ground level? **Choose by circling either (a) or (b) and then explain your answer** (5)



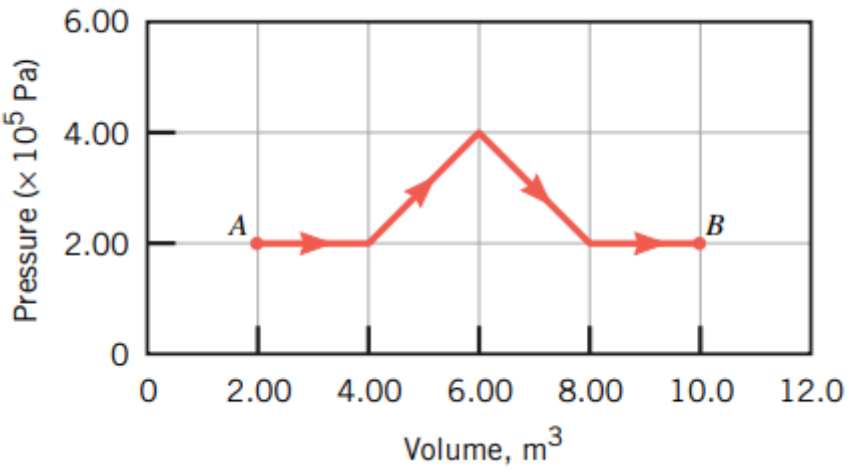
Question 4: Thermodynamics **[15]**

4.1 Explain your own understanding of the term “Thermodynamics”. (3)

4.2 Mention an example where the theory of thermodynamics is applied in solving real-life problems. (1)

4.3 Explain what you understand by the term" quasi-static process". (2)

4.4 A monatomic ideal gas expands from point A to point B along the path shown in the drawing.



4.4.1 Determine the work done by the gas. (2)

4.4.2 The temperature of the gas at point A is 185 K. What is its temperature at point B? (3)

4.4.3 How much heat has been added to or removed from the gas during the process? (4)

Question 5: Alternating Current Circuits [15]

5.1 A circuit consists of a 215-Ω resistor and a 0.200-H inductor. These two elements are connected in series across a generator that has a frequency of 106 Hz and a voltage of 234 V.

5.1.1 What is the current in the circuit? (6)

5.1.2 Determine the phase angle between the current and the voltage of the generator. (4)

5.2 Explain why the sum of voltages across each circuit element is not equal to the voltage across the generator. (2)

5.3 Using your own words, explain what a resonance frequency is, and then show that the expression for resonance frequency is given by the equation $f_o = \frac{1}{2\pi\sqrt{LC}}$. (3).

Question 6: Special Relativity **[15]**

6.1 State two postulates for special relativity theory. (4)

6.2 Twins who are 19.0 years of age leave the earth and travel to a distant planet 12.0 light-years away. Assume that the planet and earth are at rest with respect to each other. The twins depart at the same time on different spaceships. One twin travels at a speed of 0.900c, and the other twin travels at 0.500c.

6.2.1 According to the theory of special relativity, what is the difference between their ages when they meet again at the earliest possible time? (9)

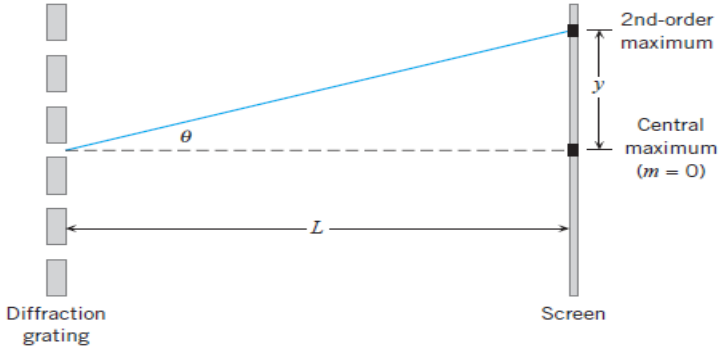
6.2.2 Which twin is older? Explain. (2)

Question 7: Wave nature of Light [15]

7.1 What is a coherent source? (2)

7.2 Do you think light is a wave? Explain. (3)

7.3 Light of wavelength 410 nm (in vacuum) is incident on a diffraction grating that has a slit separation of $1.2 \times 10^{-5}\ m$. The distance between the grating and the viewing screen is $0.15\ m$. A diffraction pattern is produced on the screen that consists of a central bright fringe and higher-order bright fringes (see the drawing).



7.3.1 Determine the distance y from the central bright fringe to the second-order bright fringe. (*Hint: The diffraction angles are small enough that the approximation* $tan\theta \approx sin\theta$.) (6)

7.3.2 If the entire apparatus is submerged in water ($n_{water} = 1.33$), what is the distance (4)

TOTAL 100