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TECHNOLOGICAL UNIVERSITY DUBLIN
TALLAGHT CAMPUS

TU936 & TU736

BSc in Sports Science & Health

Year 1

SEMESTER 2
EXAMINATIONS 2024/25

Principles of Physics

Internal Examiner:
Dr Eugene Hickey

External Examiner:

Exam Duration:
Two hours in duration
Instructions:
Answer question one and any other two questions.
Formula Sheet at end of exam paper.

Question 1 (Compulsory) (40 marks)
Answer any ten from the following sixteen parts. Each part is worth four marks

a) Express 23000J in scientific notation.
b) Convert 90μJ to mJ.
c) Convert 7800cm^3 to Litres.
d) What is the SI unit for work?
e) Fat has a density of 0.910g/cm^3. Express this density in kg/m^3.
f) A bungee jumper falls 116m from rest in a time of 5.2s. Calculate the acceleration of the diver as they fall.
g) During a traffic accident, a van of mass 3800kg collides with a stationary car of mass 1100kg. After impact the van and car stick together and move with a speed of 11m/s. Calculate the speed of the van before impact.
h) A football has a coefficient of restitution (COR) of 0.63. if it is dropped from a height of 1.4m, how high does it rebound?
i) What is the role of ADP to ATP conversion within energy processes in the body?
j) A discus rotates with a speed of 9.8Hz. Calculate the angular velocity in rads/s.
k) A seesaw is perfectly balanced when a child of 24kg sits 1.5m from the pivot and an adult sits 0.45m from the pivot on the far side. Calculate the mass of the adult.
l) A hammer thrower rotates his arm at 25rad/s. The length of his arm plus hammer is 1.95m. The mass of the hammer is 4kg. Calculate the centripetal force of the rotating hammer.
m) Calculate the moment of inertia of a medicine ball of weight 8kg and radius 17cm. The medicine ball is hollow with all its mass on the outer surface.
n) Calculate the magnitude of the vector $\vec{A} = \vec{x} - 3\vec{y}$.
o) Calculate the dot product, $\vec{A}.\vec{B}$, of the two vectors $\vec{A} = 4\vec{x} - 2\vec{y} + \vec{z}$ and $\vec{B} = -\vec{x} + 2\vec{y} + \vec{z}$.
p) Calculate the cross product, $\vec{A}x\vec{B}$, of the two vectors $\vec{A} = \vec{x} - 3\vec{y} - 2\vec{z}$ and $\vec{B} = 2\vec{x} + 3\vec{y} + \vec{z}$.

Question 2 **(30 marks)**

a) What is meant by power? (4 marks)
b) What are the units for power? (4 marks)
c) Is power a vector or a scalar? (3 marks)
d) During a race, a runner accelerates smoothly from 4m/s to 7m/s over a distance of 53m.
   i) Show that their acceleration is 0.311m/s^2 (4 marks)
   ii) Show that the time taken to change their velocity is 9.64s. (4 marks)
   iii) If the runner has a mass of 55kg, show that the force they must apply to accelerate is 17.12N. (3 marks)
   iv) Show that the work done to accelerate is 907.5J. (4 marks)
   v) Calculate the power output from the runner during the acceleration. (4 marks)

Question 3 **(30 marks)**

a) What is meant by moment of inertia of a body? (3 marks)
b) What is meant by *torque?* (3 marks)
c) A cyclist accelerates from 6m/s to 10m/s during a sprint. The acceleration takes 6s. The bicycle wheel radius is 0.622m and a mass of 0.8kg
   i) Calculate the acceleration of the bicycle during the 6s. (3 marks)
   ii) How far does the bicycle travel during the 6s? (3 marks)
   iii) Show that the initial angular velocity of the bicycle wheel when it is travelling at 6m/s is 9.65rad/s (3 marks)
   iv) Show that the final angular velocity of the bicycle wheel when it is travelling at 10m/s is 16.08rad/s (3 marks)
   v) Show that the angular acceleration of the bicycle wheel during the 6s is 1.07rad/s^2. (3 marks)
   vi) Show that the moment of inertia of the bicycle wheel is 0.310kgm^2. (3 marks)
   vii) Calculate the necessary torque applied to the bicycle wheel to cause the angular acceleration. (3 marks)
   viii) If the cycle pedal is 0.12m long, and assuming 90% of the cyclist's torque gets applied to the wheels, what is the force applied by the rider to the pedal? (3 marks)

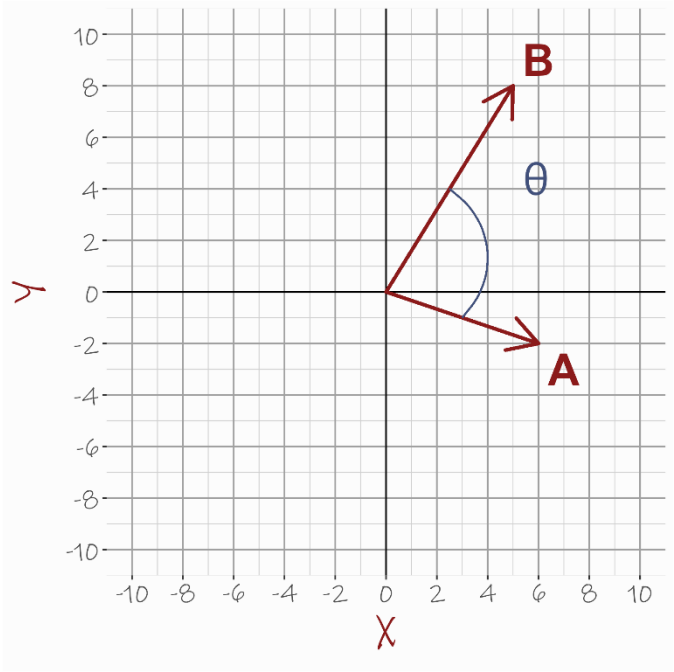
Question 4 **(30 marks)**

a) Explain the difference between a vector and a scalar. (3 marks)

b) Which of the following are vectors and which are scalars?

i) Power
ii) Force
iii) Velocity
iv) Acceleration
v) Time
vi) Coefficient of friction
vii) Temperature
viii) Altitude
ix) Angular velocity
x) Torque
xi) Pressure
xii) Frequency (6 marks)

d) For the two vectors shown below:



i) Calculate their components, A_x, A_y, B_x, and B_y. (3 marks)

ii) Calculate their dot product, $\vec{A} \cdot \vec{B}$. (3 marks)

iii) Calculate the magnitude of $\vec{A}$ (3 marks)

iv) Calculate the magnitude of $\vec{B}$. (3 marks)

v) Calculate the cosine of the angle between $\vec{A}$ and $\vec{B}$. (3 marks)

vi) Calculate the angle, θ, between $\vec{A}$ and $\vec{B}$. (3 marks)

vii) Calculate the size and direction of the cross product, $\vec{A} \times \vec{B}$ (3 marks)

Useful Equations & Constants

Density = mass / volume

$v = v_0 + at$

$s = v_0t + \frac{1}{2} at^2$

$v^2 = v_0^2 + 2as$

$s = (v + v_0)t/2$

$p = mv$

$W = mg$

$F_{fric} = \mu F_{reac} = \mu mg$

$P.E. = mgh$

$K.E. = \frac{1}{2} mv^2$

$$COR = \frac{v_{A_{final}} - v_{B_{final}}}{v_{A_{initial}} - v_{B_{initial}}}$$

$$COR = \sqrt{\frac{bounce\ height}{drop\ height}}$$

$\omega = 2\pi f$

$T = 1/f$

$v = \omega r$

$a = v\omega = \omega^2 r = v^2/r$

$T = F\ d$

$\omega = \omega_0 + \alpha t$

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

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

$\theta = (\omega + \omega_0)t/2$

$L = I\ \omega$

$T = I\alpha$

$I_{disc} = \frac{1}{2}MR^2$

$I_{ball} = \frac{2}{5}MR^2$

$RKE = \frac{1}{2}I\omega^2$

$\vec{A} \cdot \vec{B} = A_xB_x + A_yB_y$

$\vec{A} \cdot \vec{B} = |\vec{A}|\ |\vec{B}| \cos\theta$

$$\vec{A} \times \vec{B} = (A_yB_z - A_zB_y)\vec{x} + (A_zB_x - A_xB_z)\vec{y} + (A_xB_y - A_yB_x)\vec{z}$$

$g = 9.81 m/s^2$

1 calorie = 4184J

Energy production: 21kJ / L of O_2