**IAES International Journal of Robotics and Automation (IJRA)**
Vol. 15, No. 4, December 2026, pp. 1033~1040
ISSN: 2722-2586, DOI: 10.11591/ijra.v15i4.pp1033-1040 

# Low-cost smartphone sensor platform for centripetal and vibrational dynamics analysis of domestic rotors with relevance to robotic systems

**Vani Sharma[1], Vijay Kumar[2], Praveen Pathak[3]**
[1]Department of Physics, Graphic Era Hill University, Dehradun, India
[2]Dhanuri P.G. College, Dhanauri, India
[3]Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India

**Article Info**

***Article history:***

Received Apr 30, 2025
Revised Jun 10, 2026
Accepted Nov 10, 2026

***Keywords:***

Accelerometer
Gyroscope
Magneto meter
Smartphone
Vibrations

**ABSTRACT**

Smartphone technology provides an easy-to-reach and low-cost alternative for physics experiments. In this research, the smartphone application Phyphox was used to calculate vibrations and circular motion within a top-loading washing machine. Two experiments were performed on a Samsung Eco-Bubble 10-kg top-load washing machine. The first experiment analysed the relationship between centripetal acceleration and angular velocity at distinct distances (15, 30, 45, 60, and 75 cm) from the centre of the smartphone. The second experiment evaluated vibrational peaks across distinct spin cycles under fluctuating load conditions, involving an empty drum, a 2 kg uneven load, a half-filled drum, and a fully loaded drum. Data documented by the smartphone's built-in sensors displayed an obvious linear relationship amidst centripetal acceleration and the square of angular velocity for distinct distances from the centre, validating the theoretical projection of circular motion, $a_c = \omega^2 R$. Also, different vibration trends were observed throughout spin cycles and load situations. These findings authenticate the credibility of smartphone sensors for real-time motion characteristics. Also, it showcases their capacity in system monitoring, anomaly detection, defect detection and smart control in robotics and automated systems. This technique links theoretical physics with real-world testing.

*This is an open access article under the CC BY-SA license.*

***Corresponding Author:***

Vani Sharma
Graphic Era Hill University
Dehradun, Uttarakhand
Email: vanisharma9oct1997@gmail.com

## 1. INTRODUCTION

In today's automated world, smartphones have become a necessary part of everyone's life, particularly among students [1]. During the COVID-19 pandemic, smartphones became more significant for social networking and education [2]. Mobile technology supplements pedagogy improves the partnership between students and teachers and reinforces problem-solving skills. These make it easy for students to analyse the problem and apply it in real-world situations [3]. Students can easily execute various experiments by using a smartphone at home; no costly equipment is required [4]. In Physics, smart applications can be used for both qualitative and quantitative experiments across a wide range of areas. These applications offer mobility and can replace heavy equipment [5]. Mobile learning makes it easy for students to learn physics concepts through practical activities [6]. In this study, the smartphone application "Phyphox" is used to investigate the operation of an automatic washing machine under different conditions. No other mechanical

equipment is used. Vibrations were observed inside the washing machine during the washing and spin cycles using an accelerometer sensor in Phyphox [7]. The main goal of this experiment is to study realistic vibrations using an accelerometer sensor. Phyphox has built-in sensing capabilities that allow it to directly access a smartphone and enable users to learn and perform a variety of experiments [8]. Phyphox is an ideal, novel tool for use in classrooms, as most sensors are readable and their measurement data is presented visually. Most undergraduate physics curricula include mechanical oscillations as a key topic, and several writers have recommended laboratory activities on the subject [9]. Many smartphone-based physics experiments have been proposed in the literature recently. These experiments utilize the accelerometer, gyroscope (angular-velocity sensor), magnetometer, proximeter, luxmeter (ambient light), pressure sensor, and other built-in smartphone sensors [10]. The use of smartphones in schools for mobile learning has drawn criticism. The Phyphox website also provides complete instructions for physics experiments that can be done using the app [11]. Mobile learning appears to be a more engaging form of training that may pique students' interest and motivation more than traditional classroom instruction or textbook knowledge [12]. The use of these sensors really opens the door to novel studies that enable angular velocity to be measured. Recently, rotation sensors have been used to examine angular momentum conservation [13]. Multiple physical parameters can be measured simultaneously using a smartphone sensor [14]. A combination of smartphone technology and robotics improves the flexibility and adaptability of modern robotics systems by enabling complex real-time control, sensor data collection, and wireless communication [15]. Using Bluetooth links, mobile robots can be easily controlled remotely from smartphones. To make robotics more approachable and engaging for students, educational robotics kits often use cellphones for both programming and monitoring robot behaviour [16]. These sensors provide real-time information regarding the robot's direction, movement, and orientation. This data is collected by the Phyphox application and then wirelessly sent to the robot's microcontroller [17]. The microcontroller then uses this data for navigating through challenging settings with precise motion control, avoiding collisions. This approach is not expensive and is user-friendly as well. It uses the complex sensors in cellphones for robotic applications [18]. A wireless robot mobile unit helps in enabling flexible operations [19]. It also eliminates the need for long cables, thereby decreasing entanglement risks and helping the robot to perform different tasks [20]. Sensors are devices that compute and identify physical changes, such as vibration, pressure, or light, and convert them into electrical signals for observation [21]. They are helpful in transmitting and collecting data in wireless sensor networks (WSNs) for uses such as smart automation, agriculture, healthcare, and environmental monitoring, smoothly linking the real world with digital systems [22]. This study reveals that a smartphone having the Phyphox application can act as a low-cost mobile sensor platform for calculating washing machine vibrations with the help of an accelerometer and a gyroscope. The research explores the relationship between angular velocity, centripetal acceleration, and centrifugal force, explaining their importance and the mechanical wringing action [23]. Real-time capturing of sensor data under varying load conditions gives insight into machine vibrations, enabling safer and more efficient dryer operation. The experiment also connects to robotics, where smartphone sensors supply real-time exposure and motion data for navigation and control, making robotics education user-friendly [24]. Overall, smartphone-based experiments give an opportunity to overcome traditional laboratory hurdles, fostering higher-order thinking and practical learning. The Phyphox application makes experiments easier and more precise by enabling students to identify, scrutinize, and study the characteristics of sound waves in real time [25]. In most places, ease of use is limited by costly and maintenance-intensive equipments, with different facilities required for traditional physics investigations, especially in remote settings. While vibration studies of equipment such as washing machines need precise sensors that are not typically available in common and standard labs, the static nature of these tests reduces the understanding of dynamic physical concepts.

## 2. METHOD

The experiment was performed using a Samsung 10-kg top-loading automatic washing machine in spin mode. The washing machine has multiple preset spin settings, ranging from low (400–500 RPM) to extra-high (1000–1200 RPM), in here spin settings 1-5 were considered. To gather this data, a smartphone running the Phyphox application having a built-in triaxial accelerometer was used for calculating the machine's response during rotation. To maintain the same orientation relative to the rotating drum, the smartphone was calibrated, and external vibration sources were minimised. The smartphone was carefully attached to the inner wall of the washing machine drum using adhesive tape, ensuring the y-axis was aligned with the dominant direction of centrifugal force and gravity during rotation. This allowed measurement of acceleration components in both directions. The setup used to calculate acceleration is shown in Figure 1. The x and z axes have smaller magnitudes, providing minimal information about the dynamics of rotation. As a result, the y-axis illustrates how spin and load circumstances affect system behaviour. The accelerometer

sensor was calibrated, and external vibration sources were minimised before data collection. Measurement was taken under four different load conditions: empty drum, uneven load (2 kg), half-filled (5 kg), and Fully-filled drum, as shown in Figures 1(a) to 1(c), respectively. Acceleration figures for Spin-1 through Spin-5 were recorded precisely and carefully for all loading situations. While collecting data, each reading was repeated four times, and the average values were used to ensure reliable results. During the spin cycle, the drum's vibration is recorded by the accelerometer sensor in the Phyphox application. Some measurement uncertainty occurs primarily from calibration drift and minor device discrepancies in load repositioning during rotation. Experiments were executed under controlled conditions by minimising external vibrations.




(a) (b) (c)

Figure 1. Setup of washing machine for calculating the acceleration (a) for an empty drum, (b) for an uneven load, and (c) for a filled drum.

## 3. RESULTS AND DISCUSSION

### 3.1. Mathematical relation

For an object moving in a circular path (like clothes in a washing machine drum), the centripetal acceleration,

$$a_c = \omega^2 R$$

where centripetal acceleration (m/s$^2$), directed towards the center of the drum, $\omega$=Angular velocity (rad/s), R=Distance from the smartphone to the axis of the machine's drum. This formula was experimentally verified by placing a smartphone with a sensor at different distances inside the drum, measuring centripetal acceleration and angular velocity, and confirming the linear relation between ac and $\omega^2$r. Figure 2 represents the centripetal acceleration as a function of the angular velocity for various distances, and Figure 3 represents the relationship between centripetal acceleration and angular velocity squared at various distances. These figures show that both magnitudes are related by the established relationship, as indicated by linear and parabolic fits, where R is the distance between the washing machine's axis and the smartphone. The smartphone's position doesn't affect the relation between angular velocity and centripetal acceleration.

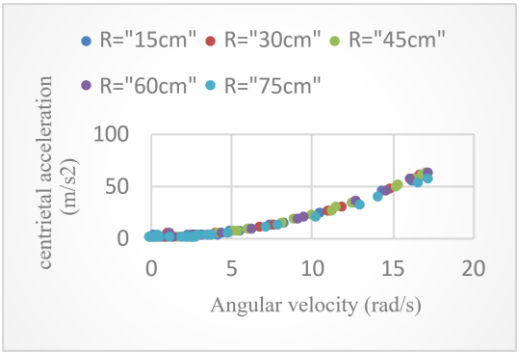


Figure 2. For various distances, the centripetal acceleration as a function of the angular velocity

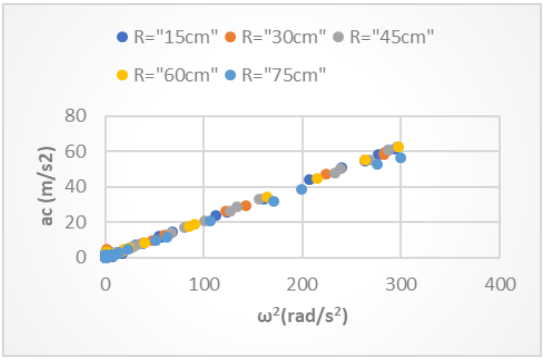


Figure 3. The relationship between centripetal acceleration and angular velocity squared at various distances

### 3.2. Vibrational analysis during different spin cycles

Due to the effect of load imbalance on vibrations, the centrifugal force generated is,

$$F = mr\omega^2$$

where $m$ is the unequal load mass, r is the radius $(m)$, and the distance from the centre of the drum to the point of measurement. This radius causes the drum to vibrate, which generates additional time-varying acceleration beyond the baseline centripetal acceleration. The graphs obtained by Phyphox reveal these vibrations as spikes superimposed on the steady ac associated with uniform circular motion.

The total acceleration (t) sensed in the drum is given by

$$A_{total}(t) = a_c(t) + a_v(t) = \omega^2 r + a_v(t)$$

where, $a_c$ = steady centripetal acceleration, which depends on angular velocity and radius, $a_v$ is a time-dependent vibrational acceleration caused by uneven mass. If the load is balanced.

$$\mathrm{a_v}(t) = 0,\ a_{total} \approx \omega^2\ \mathrm{r}$$

Hence, proven by the first experiment. For unbalanced. $a_v\ (t) \neq 0$ peaks and oscillations are obtained.

The vibration data are recorded for 200 seconds around the different spin cycles (1 to 5) under four load conditions (empty drum, uneven load 2 kg, half-filled drum, filled drum). The graphs represent time-domain data; the X-axis shows time in seconds, and the Y-axis shows absolute acceleration. All graphs are described in three phases (initial phase, middle phase, and deceleration phase). For Spin cycle 1 at low rotational speed, a balanced operation is shown in Figure 4. In the initial phase, acceleration remains close to the gravitational value (~9.7-10 m/s2) across all cases. This shows a stable start-up with minor fluctuations from motor start-up. In the middle phase, clear load-dependent behavior was observed. The empty drum Figure 4(a) shows minimum variation in acceleration, whereas Figure 4(b) for uneven load shows moderate acceleration due to uneven mass distribution. The half-filled drum in Figure 4(c) shows broader, more continuous fluctuations reaching ~ 12m/s$^2$. The broadest and most erratic variation in acceleration peaks is seen in the case of a fully loaded drum (Figure 4(d)). This is due to increased centrifugal forces.

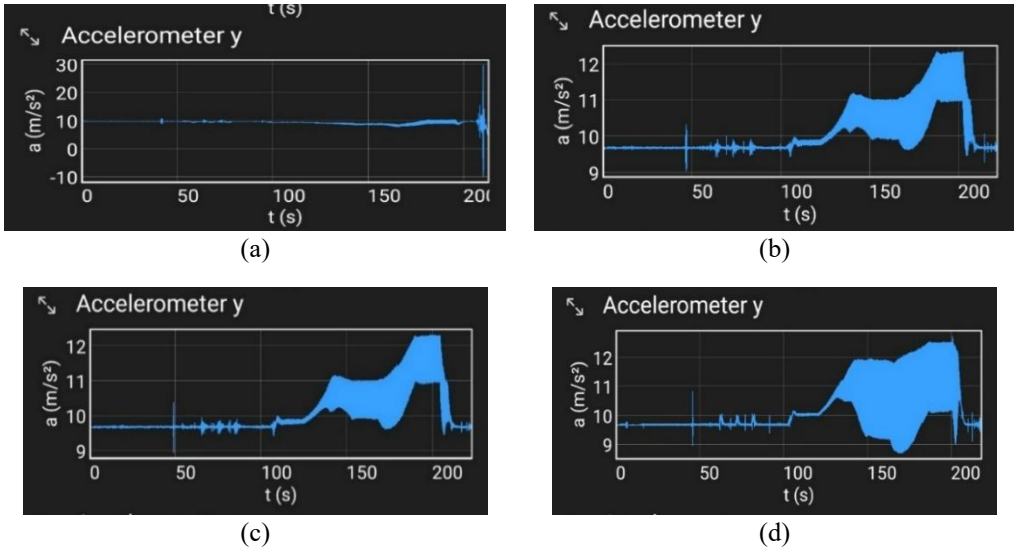


Figure 4. Graphs for absolute acceleration with respect to time for spin cycle -1 (a) for empty drum, (b) uneven load (2 kg), (c) half-filled drum, and (d) filled drum

For spin cycles 2 and 3, as the spin speed increases, the magnitude of acceleration increases for all load conditions, as shown in Figures 5 and 6. The graph for the empty drum shown in Figure 5(a) and in Figure 6(a) remains stable at the initial phase. In contrast, the unevenly loaded drum shown in Figure 5(b), Figure 6(b), and the half-filled drum in Figure 5(c), Figure 6(c) show broader acceleration. But a filled drum consistently reflects the highest vibrational peak, highlighting the combined effect of increased centrifugal

force with a loaded drum, as shown in Figures 5(d) and 6(d). During deceleration, sharp ephemeral peaks of superior magnitude are observed. Overall, spin cycles 2 and 3 exhibit greater load reliance and higher vibrational intensity due to the higher angular velocity.

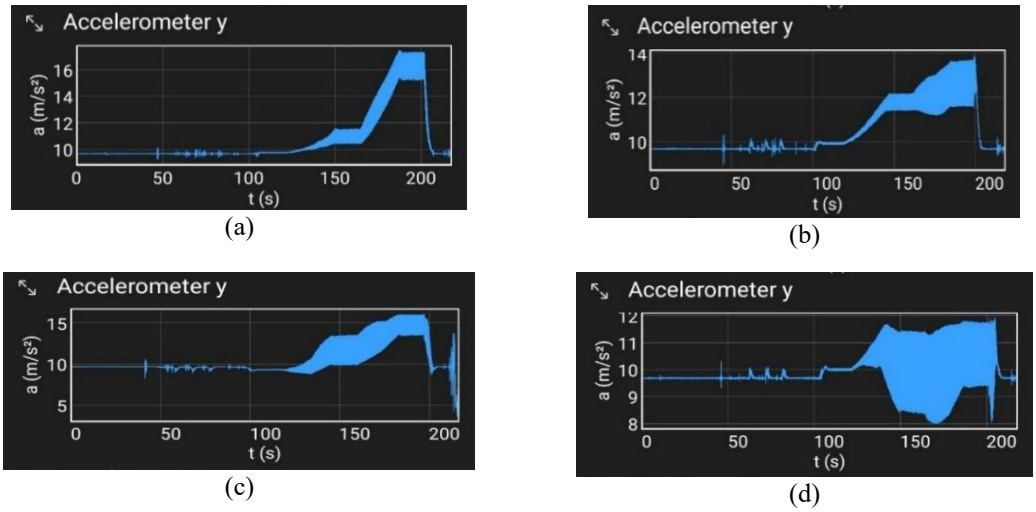


Figure 5. Graphs for absolute acceleration with respect to time for spin cycle -2 (a) for empty drum, (b) uneven load (2 kg), (c) half-filled drum, and (d) filled drum

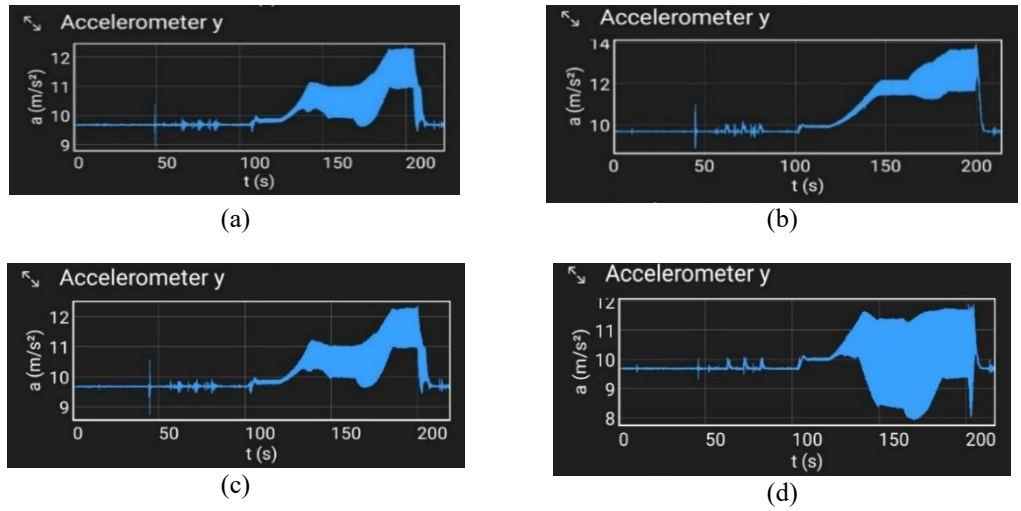


Figure 6. Graphs for absolute acceleration with respect to time for spin cycle -3 (a) for empty drum, (b) uneven load (2 kg), (c) half-filled drum, and (d) filled drum

For spin cycle 4, Figure 7 shows the absolute acceleration for spin cycle 4. Marginal shifts are observed in the empty drum in Figure 7(a), indicating more stable rotation. Due to eccentric mass allocation, the irregular load in Figure 7(b) gives the best vibrational peaks. Figure 7(c) shows bigger, more irregular peaks for a half-filled drum because of the dynamic load setting. The filled drum in Figure 7(d) provides higher, broader acceleration peaks, reflecting increased centrifugal force and curtailed rotational stability.

Figure 8 shows the acceleration for Spin cycle 5. These graphs represent the highest operating mode. The highest vibrational range and maximum acceleration magnitude shows that both high rotational speed and drum load have a meaningful impact. The empty drum Figure 8(a) appears balanced with modest vibration levels. The unevenly loaded 2 kg drum (Figure 8(b)) and the half-filled drum (Figure 8(c)) reflect much increased acceleration and greater oscillations because of load asymmetry. In contrast, the most noteworthy response is observed in the filled drum in Figure 8(d), exhibiting large-amplitude oscillations and noticeable transients during deceleration, reflecting instability and a peak in centrifugal force. Overall, Spin cycle 5 highlights the importance of high spin speed in increasing mechanical stress and vibration, especially under heavy and uneven loads.

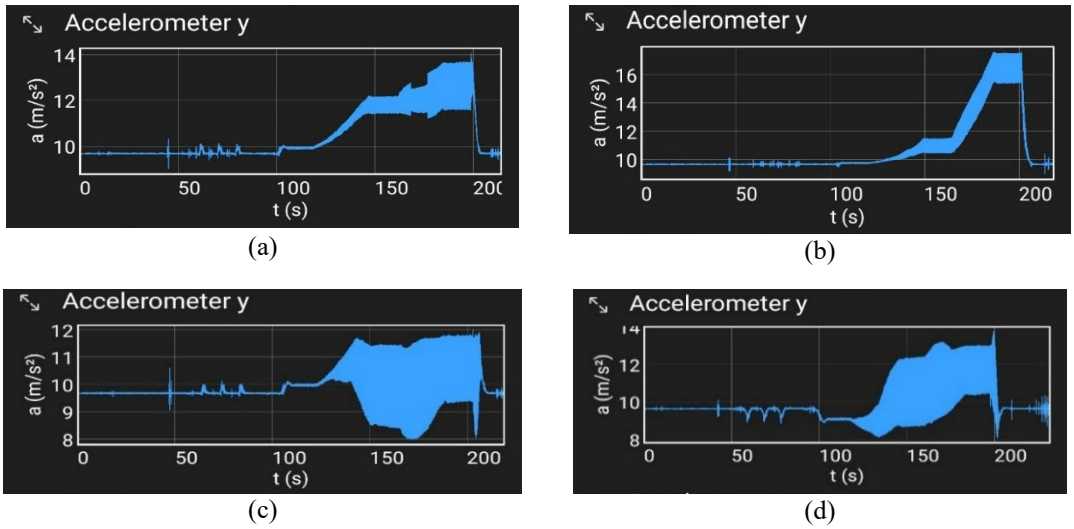


Figure 7. Graphs for absolute acceleration with respect to time for Spin cycle- 4 (a) For Empty Drum, (b) uneven load (2kg), (c) Half-filled drum, (d) filled drum

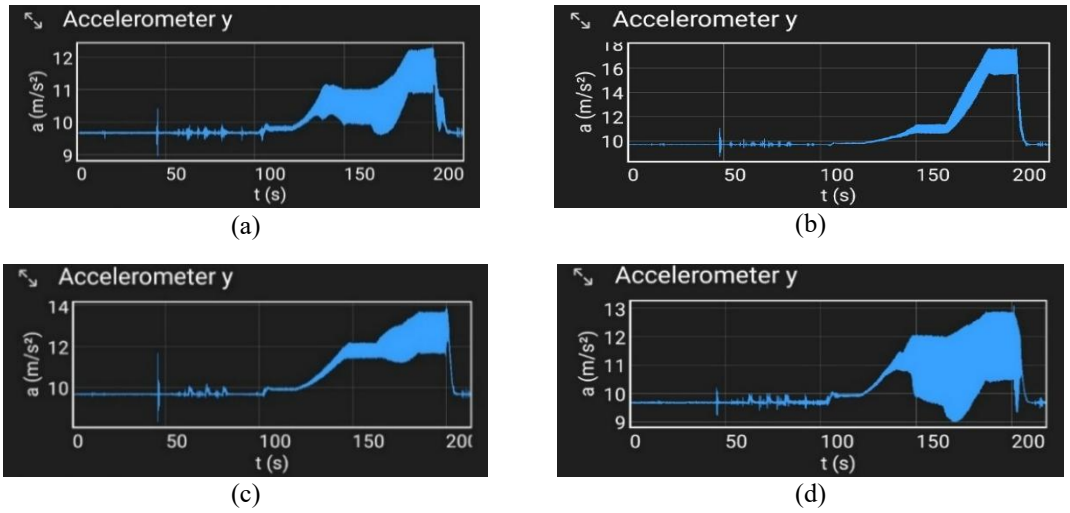


Figure 8. Graphs for absolute acceleration with respect to time for Spin cycle-5 (a) For Empty Drum, (b) uneven load (2 kg), (c) Half-filled drum, (d) filled drum

## 4. CONCLUSION

In this study, a fundamental association between centripetal acceleration and angular velocity was established. Additionally, the vibrational behaviour of different spin cycles under different load conditions was examined using smartphone sensors. The outcome shows that both the magnitude of acceleration and vibrational intensity increase in an organized manner as the spin speed and load increase. At lower spin cycles, the system remains stable, particularly for an empty drum, but at higher spin cycles it exhibits significant load-dependent dynamic behavior. At high spin speeds, under-filled and uneven load conditions, the most significant fluctuations are due to increased centrifugal force, load, and mechanical stress. These results show that low-cost smartphone sensors are feasible for dynamic analysis of home electromechanical systems and emphasize the significance of efficient load balancing and vibration monitoring. Both experiments demonstrate how easy and useful it is to examine a washing machine's dynamic behavior using a smartphone. Because they require costly, wired equipment that is difficult to integrate with a revolving disk, such tests are difficult to perform using standard laboratory sensors. A smartphone, on the other hand, provides an inexpensive, highly accessible way to measure vibration and acceleration in operational environments. This smartphone-based vibration measurement method can be enabled for real-time condition monitoring and imbalance identification in robotic and automated systems in future research. The approach may support improved control, stability, and maintenance of robotic machines.

**ACKNOWLEDGMENTS**

The management of Graphic Era Hill University, Dehradun, is commended by the authors for providing all required facilities.

**FUNDING INFORMATION**

No external funding is involved in the proposed manuscript.

**AUTHOR CONTRIBUTIONS STATEMENT**

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vani Sharma | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | |
| Vijay Kumar | ✓ | ✓ | | | | ✓ | | | | ✓ | ✓ | | | |
| Praveen Pathak | ✓ | ✓ | ✓ | | | | | | | ✓ | ✓ | | ✓ | ✓ |

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

**CONFLICT OF INTEREST STATEMENT**

The authors declare no conflict of interest. Without any funding or commercial assistance, this study was carried out independently with the express goal of improving scientific instruction by utilising readily available technologies, such as a home washing machine and the Phyphox app.

**DATA AVAILABILITY**

The authors attest that the data supporting the study's conclusions are available in the article and its references. All processed data used for analysis are provided in the publication. The acceleration datasets were obtained under controlled spin-cycle conditions using a smartphone-based sensor application.

**REFERENCES**

[1] Q. Chen, N. S. B. M. Sin, A. N. bin Mohd Isa, and D. Chen, "Investigation on the association between college students' smartphone-related behaviours and sleep quality during COVID-19," *Cancers*, vol. 20, no. 4, Apr. 2025.
[2] M. Li, J. Duan, Y. Liu, J. Zou, X. Yang, and H. Zeng, "The habitual characteristic of smart phone use under relevant cues among Chinese college students," *Frontiers in Psychology*, vol. 14, Sep. 2023, doi: 10.3389/fpsyg.2023.1218886.
[3] L. Sukariasih, Erniwati, L. Sahara, L. Hariroh, and S. Fayanto, "Studies the use of smartphone sensor for Physics learning," *International Journal of Scientific and Technology Research*, vol. 8, no. 10, pp. 862–870, Oct. 2019.
[4] M. Monteiro, C. Cabeza, and A. C. Martí, "Exploring phase space using smartphone acceleration and rotation sensors simultaneously," *European Journal of Physics*, vol. 35, no. 4, Jul. 2014, doi: 10.1088/0143-0807/35/4/045013.
[5] J. Kuhn and P. Vogt, *Smartphones as Mobile Minilabs in Physics*, 1st ed. Cham: Springer International Publishing, 2022. doi: 10.1007/978-3-030-94044-7.
[6] M. Á. González and Others, "Mobile phones for teaching Physics," in *Proc. TEEM'14: 2nd International Conference on Technological Ecosystems for Enhancing Multiculturality*, Oct. 2014, pp. 349–355. doi: 10.1145/2669711.2669923.
[7] M. Monteiro, C. Stari, C. Cabeza, and A. C. Marti, "Physics experiments using simultaneously more than one smartphone sensors," *Journal of Physics: Conference Series*, vol. 1287, no. 1, Aug. 2019, doi: 10.1088/1742-6596/1287/1/012058.
[8] S. Staacks, S. Hütz, H. Heinke, and C. Stampfer, "Advanced tools for smartphone-based experiments: Phyphox," *Physics Education*, vol. 53, no. 4, pp. 1–6, 2018, doi: 10.1088/1361-6552/aac05e.
[9] Y. F. Ilmi, A. B. Susila, and B. H. Iswanto, "Using accelerometer smartphone sensor and Phyphyox for friction experiment in high school," *Journal of Physics: Conference Series*, vol. 2019, no. 1, Oct. 2021, doi: 10.1088/1742-6596/2019/1/012008.
[10] M. Monteiro, C. Cabeza, A. C. Marti, P. Vogt, and J. Kuhn, "Angular velocity and centripetal acceleration relationship," *The Physics Teacher*, vol. 52, no. 5, pp. 312–313, 2014, doi: 10.1119/1.4872422.
[11] M. Grossi, "A sensor-centric survey on the development of smartphone measurement and sensing systems," *Measurement: Journal of the International Measurement Confederation*, vol. 135, pp. 572–592, Mar. 2019, doi: 10.1016/j.measurement.2018.12.014.
[12] A. V Zdeshchyts and V. M. Zdeshchyts, "Measuring Earth's mean density using BYOD technology," *Journal of Physics: Conference Series*, vol. 2611, no. 1, Oct. 2023, doi: 10.1088/1742-6596/2611/1/012007.
[13] S. Staacks, "Phyphox - physical phone experiments." 2024. [Online]. Available: https://phyphox.org
[14] F. Bellas, M. Naya-Varela, A. Mallo, and A. Paz-Lopez, "Education in the AI era: a long-term classroom technology based on

intelligent robotics," *Humanities and Social Sciences Communications*, vol. 11, no. 1, Oct. 2024, doi: 10.1057/s41599-024-03953-y.
[15] A. A. Sneineh, W. A. Salah, M. Elnaggar, and M. Abuhelwa, "Development and implementation of a mobile robot for grouting floor tile joints," *IAES International Journal of Robotics and Automation*, vol. 14, no. 2, pp. 151–161, Jun. 2025, doi: 10.11591/ijra.v14i2.pp151-161.
[16] F. R. Seke and I. P. Tamba, "Development of robot motion direction based on microcontroller with compass sensor," *IAES International Journal of Robotics and Automation*, vol. 13, no. 2, pp. 122–130, Jun. 2024, doi: 10.11591/ijra.v13i2.pp122-130.
[17] A. Muneer and Z. Dairabayev, "Design and implementation of automatic painting mobile robot," *IAES International Journal of Robotics and Automation (IJRA)*, vol. 10, no. 1, p. 68, Mar. 2021, doi: 10.11591/ijra.v10i1.pp68-74.
[18] Ompal, N. Kumar, V. M. Mishra, and A. Kumar, "Wireless sensor networks protocols, applications, and network-on-chip communications," *IAES International Journal of Robotics and Automation*, vol. 13, no. 3, pp. 338–350, Sep. 2024, doi: 10.11591/ijra.v13i3.pp338-350.
[19] R. Hurd and D. Grote, "Smartphone-based labs for engineering vibration class," 2024. doi: 10.18260/1-2-1112-44951.
[20] N. A. Azizah, A. Hutami, and N. Norlita, "The advancement of smartphones as learning media in the modern era (in Indonesia): kecanggihan smartphone sebagai media pembelajaran di era modern," *BJIE (Batusangkar Journal of Historical Education)*, vol. 3, no. 1, pp. 65–73, May 2023, doi: 10.21093/bjie.v3i1.6333.
[21] E. P. Raharja, M. Irianti, R. D. Lestari, and Y. Kabes, "Development of a Physics experiment module based on smartphone sensors on mechanics for high school students," *Jurnal Riset dan Kajian Pendidikan Fisika*, vol. 11, no. 1, pp. 1–10, Apr. 2024, doi: 10.12928/jrkpf.v11i1.634.
[22] P. Cumber, "Visualising mechanics: washing machine dynamics," *International Journal of Mathematical Education in Science and Technology*, vol. 52, no. 4, pp. 626–652, Apr. 2021, doi: 10.1080/0020739X.2020.1794070.
[23] A. Mardani and S. Ebrahimi, "Simultaneous surface scanning and stability analysis of wheeled mobile robots using a new spatial sensitive shield sensor," *Robotics and Autonomous Systems*, vol. 98, pp. 1–14, Dec. 2017, doi: 10.1016/j.robot.2017.08.007.
[24] M. Ziese, "Symbolic regression as AI-based tool for the analysis of smartphone experiments," *Physics Education*, vol. 60, no. 4, p. 45025, Jul. 2025, doi: 10.1088/1361-6552/addea1.
[25] N. Imtinan and H. Kuswanto, "The use of Phyphox application in Physics experiments: A literature review," *JIPF (Jurnal Ilmu Pendidikan Fisika)*, vol. 8, no. 2, p. 183, May 2023, doi: 10.26737/jipf.v8i2.4167.

## BIOGRAPHIES OF AUTHORS



**Vani Sharma** received the M.Sc. degree in physics from Banasthali Vidyapith. She is currently working as a research scholar at Graphic Era Hill University. Her research interests focus on smartphone-based experiments and low-cost instrumentation. She can be contacted at Vanisharma9oct1997@gmail.com.



**Vijay Kumar** received the M.Sc. degree in physics and a Ph.D. degree in physics from Gurukul Kangri Vishwavidyalaya. He is currently working as the principal at Dhanauri PG College, Haridwar. He can be contacted at drvijaykumar.geu@gmail.com.



**Praveen Pathak** is a scientific officer at Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mumbai, India. He holds a Ph.D. in condensed matter physics and is currently interested in teaching physics using smartphones and cost-effective experiments. He assists in the theoretical aspects of the Physics Olympiad and National Initiative on Undergraduate Science programs in India. He can be contacted at praveen@hbcse.tifr.res.in.